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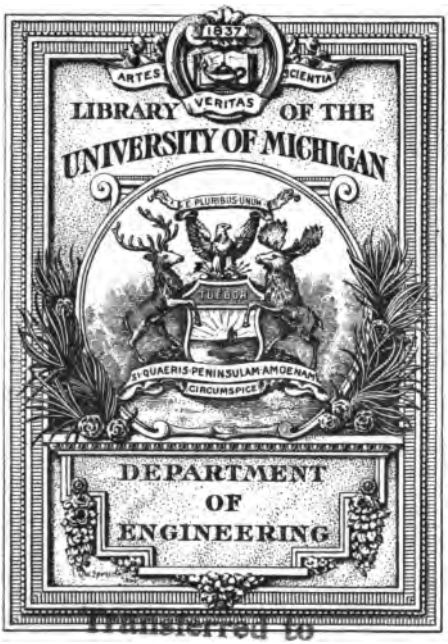

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THE MICHIGAN

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. . . CONTAINING THE . . .

Proceedings of the Michigan Engineering Society for

1889.

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ENGINEERS' ANNUAL,

CONTAINING THE

PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY,

FOR 1889.

The Eleventh Annual Convention will be held in January, 1890, on call of the Board of Directors.

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MICHIGAN ENGINEERING SOCIETY.

Papers and Discussions at the Tenth Annual Convention, held at Lansing, Jan. 22-24, 1889.

PRESIDENT'S ADDRESS.

Members of the Michigan Engineering Society: —

It was with much hesitancy that I assumed the office which by a majority of your ballots, was made imperative. And now to think of giving any direction to your thoughts or plans, seems like presumption itself. I am certainly very grateful for the honor conferred, and like a boy with his pocket full of goodies belonging to another, will promise "not to do so any more." At this our Tenth Annual Convention, held at the Capitol, where our first organization was effected, a retrospective view shows the wisdom of organization. The proceedings of other similar societies, nearly all formed since this one, evince a growing impulse toward improvement. So much is this true that a copy of society proceedings is received as a long-desired letter from a friend, and studied through and through, to learn what others are doing. These exchanges will in time make a useful addition to our libraries, and I recommend that they be carefully filed and bound. It is the active worker and searcher after facts, in these days, who stands foremost; and our Society, as such, and each individual member, should be no exception to the law. The duty is thrust upon us, and two words express the situation — *Do* or *die*.

It will not do to say we have done very well so far, and are satisfied with our attainments. "The mill will never grind with the water that is past." There is room enough up higher for the energetic surveyor and engineer, and he can always be improving from observation, study, and the teaching or experience of others.

And how better can we make advancement than by the association with others which this Society gives, and by making others' needs our own? We are not here to hear sweet words and dulcet melodies. The daily duties in office and field may well be sus-

pended; and while we profess to meet as business men, on business errands, a strict discussion of the program is our repast, and all the panacea we expect or need. Our doors are always open, and if a stranger or an honorable legislator walks this way, we shall not say him "nay." The only admission is, to such, a modest notice or recognition of our body, among other societies which grace the pages of the "Red Book." Perhaps, then, through a little official courtesy, and by keeping company with the Bee-keepers and Stock-breeders, we can make a decent appearance among some of our own Michigan people; and they may learn that nine years ago some of the lonely and disconsolate surveyors met around the dais of the pioneer room of the Capitol, and organized what has now grown to be the incorporated "Michigan Engineering Society;" that it takes hold of the live questions of surveying and civil and mechanical engineering, and we believe the more aid and encouragement it receives, the better for the State at large. Surely the grave questions of boundary lines and corners, the proper platting of villages, the location of drains and highways, the construction of bridges, the improvement of railways and rolling stock, the warming and sewerage of dwellings, the best management of steam for various purposes, and many other such topics, are directly connected with our substantial growth and progress as a State. What other profession does more? What other can better wield the destiny of any people? Its failures are far-reaching, and Panama follies are turned into a Pandora's box of all evil. Our own State is large, diversified, and calls for the best surveyors, engineers, and mechanics. Its progress even in the last twelvemonth, in railroad building, the platting of new villages, and the starting of manufactories calling for all kinds of machinery, is surprising. It would be the more so were it not that Michigan men have become accustomed to Michigan speed. We can realize how fast the driving-wheels go, by *dropping out of the car!* Are these statements too extravagant? Not intentionally. The facts bear us out. Nov. 6, 1888, Michigan cast 475,356 votes for presidential electors, which, at the usual estimate of population, would give 2,200,897, an increase in the last four years of 344,797. We said our State calls for the *best* surveyors and engineers, and we mean that each shall find his proper place in due time. The skimmed milk is in one jar, the cream in another. When the people learn by experience that work half done is dear at half price, and that good surveyors and engineers do not, on call, jump out of a ballot box, there will be greater advancement. The influence of this Society should be such as to say to every struggling one, "We will help you," and it should just as unmistakably discourage tramps, whether they travel along the highways with their earthly effects stowed in two old boots, or meander along the farm lines with compass and chain. What the State is doing at the Normal School, University, and Agricultural College to give a thorough

and complete course in practical, civil, mechanical, and mining engineering, and what it has lately commenced in the Mining School at Houghton, should be kept in vigorous progress. No parsimony should now cripple the good work being done. We are on the right track. The *hand* and the *brain* are *both being educated*, and by and by the young men who have gone out from these schools will have some of the shop dust to wipe off from their diplomas on to those of the kid-gloved kind who never make stir enough to raise a dust.

If the State can graduate from any of these institutions a class who would degrade intelligent labor, then just so far has it been unfaithful, and has squandered the public money. That the contrary is generally true, we believe, and the many responsible places filled by these graduates will abundantly prove.

We have reason for gratitude to the Giver of all good that our membership has suffered no loss by death since our last meeting at Kalamazoo, and for that general prosperity which prevails, and which has brought into greater requisition the engineers' services. We have had no disturbing strikes of laborers to stop engineering work, and be it said to our praise that there has been none of the trades-union spirit in which our members use the Society to make unusual and selfish demands; but all seem to be actuated by that spirit which shall better their knowledge in their respective branches of work and professional study, and thus make their united effort a public as well as a private good.

Our Secretary is to be specially commended for the neat and attractive annual report, and the several circulars and notices sent. This is a matter which requires good judgment and care to put it in the right hands for execution, and one which adds much to our proceedings. The present program brought out by the Executive Committee, in part, at their annual meeting in October last, and by the Secretary, after much correspondence, shows a most home-like and practical Michigan face. These topics are live ones, and are from those who are prepared to speak from experience. We hope it may afford sufficient variety. It has been said in our hearing that the engineers are now running this Society, and there is not a place for surveyors. If one would stop to think how dull is the music of the best hand-organ when played without intermission, and how impossible to sustain such an organization as this without due regard for each individual member, perhaps such a remark would not obtain. To my own knowledge, there has not been a session of this Society which did not afford ample opportunity to introduce any questions germane to our objects as set forth in the second subdivision of the Articles of Association.

It was thought best in the organization not to provide any standing committees, as used to be our custom, and still is with similar societies, the reason being that a committee of several members was not easy to convene, and no one member wanted to take the

work alone, when there were others who should assist. I would therefore recommend that some topics be assigned to special committees, of one member each, who will be expected to do thorough work in the line assigned him, and report at our next annual Convention.

1. It would be well to have a special committee on *Questions of Practice*, with principal reference to surveyors' work, and any member during the year may address such committee freely with any question he needs light upon, and the decision of the committee shall be rendered subject to review by the Society. It is expected, however, that if the committee is not well prepared, an answer may be made after correspondence with other members. We well recollect the day when, isolated in the Northern Michigan woods, away from any surveyor whom we could consult, and lacking guide-books, such a correspondence with an able committee of such a State organization would have been very pleasant, to say the least.

2. A special committee on *Decisions*. This committee would be able to give us at our next Convention, a resumé of any important decision of State or United States courts bearing on boundary, or any matter of interest to this Society. One member making a speciality of this will be likely to bring together the most in that department.

3. A special committee on *Photography* as applied to Engineering. Of this subject we expect more will be said before the close of this session, but as it is now prominently before us, and is somewhat of a new feature, it would be well to prepare for next year's Convention early. The committee would be expected to interest any amateur photographer to make an exhibit, or by a little effort could himself make a loan of views for use a few days. The portraits of any eminent engineers would be a very pleasant feature for reference and study, while our next Convention was held. Many useful details would suggest themselves to the committee.

There may be still other subjects which could be best prepared by a special committee of one, and if any member will call them up, we will be pleased to have him.

The advertising pages of the Annual Report are well filled, and it suggests the thought that these dealers and those who make an effort to exhibit instruments at our Conventions, are especially worthy of patronage by the members of our Society.

The annual Convention, with its social greetings, is too infrequent. So, too, are the opportunities of our members to consult together, and improve themselves by this means. It would be more than we may reasonably expect to do to meet semi-annually, as the expense to some is now considerable, and more than it would be if all our attending members purchased certificates for reduced fare. Our Society presented the anomalous condition at the last Convention of having so many who were connected with

railroads, and thereby entitled to passes, that the others were compelled to pay full fare both ways. It would seem that on account of the good work this Society is doing for the railroads, and other engineering matters, some way might be devised so that every member could be assured of getting reductions to one and one-third fare. As it is, it reduces our attendance, and discourages those who come.

In connection with the idea of more frequent meetings is this; the failure of our State Institutions to benefit the people as they might, not *per se*, but because the people at large do not demand a different course. How little is known throughout the State what is being done and what is the *daily thought* at these institutions! The students know, and so do the Professors in charge. But both probably have too much to do already. We see results when a class is graduated. Then a sweltering crowd listen to music, and the sweet patter of words set to the latest rhetorical rhythm, and they go away to come again the next year, and so on. The graduates file out from this modern Parthenon, and Michigan people have the pleasure of reading a long list of names in the catalogues. Is it not wrong to give so many advantages to the few, at the expense of the many, when both might be subserved? We have seen that the population of Michigan is over 2,200,000. Now instead of limiting our State institutions to the service of the few who are able to attend them directly, a large number of our thoughtful, studious, and isolated people should be kept constantly informed of the current thought of these schools. Is there not some way in which these superheated bodies can send a little daily or weekly warmth to the distant regions of Michigan? or cannot the people be in closer contact with them by means of the press? Take the Surveying and Engineering Departments: How much is being worked out that would be useful to every one of this class? Both successes and failures should be spread abroad. You say that this is done by occasional reports and bulletins. And we answer, they *are too occasional.* Give these schools each a good active reporter, and the means to pay him, or turn some of the usual appropriations to a different purpose, and let us know by minute reports to the daily or weekly papers *just what they are talking about.* The people are the students, and they are sitting with their feet hanging from the rough back-woods benches, listening for something from these schools. Let these enlarge their borders, so that the whole State shall be their campus! The engineers are interested in this general question with its special application to their needs, and perhaps can use their influence with the "powers that be" to bring about these desirable conditions. If so, our meeting shall not be in vain.

With a most earnest desire for the good of every member, and our best wishes for a pleasurable session, I bid you, *Speed the Program.*

GEO. E. STEELE, *Pres.*

MUNICIPAL ENGINEERING.

To the President and Members of the Michigan Engineering Society: —

GENTLEMEN: Believing it to be the duty of each member of this Society to perform his quota of the necessary work, and responding to the request of the Secretary, I present herewith a paper on "Municipal Engineering."

Municipal engineering includes the construction, care, and maintenance of streets, sewers, water-works, bridges, etc., and, in a word, is intimately connected with all kinds of municipal public works.

The subject being of such general scope, it was found necessary, in order to keep this paper within proper confines, to generalize, rather than enter much into details.

In the contemplated improvement of a city by the grading or paving of its streets, the first step to be taken is the preparation and adoption of general plans, in order that, as these improvements are made from year to year, the several parts shall work harmoniously into the whole.

Before proceeding with the preparation of general plans, bench marks should be established throughout the city, with reference to some assumed datum line; levels should then be taken, extending over the entire limits of the city, and from these levels a topographical map be made in order that the engineer may intelligently prepare a grade map, or plan, for street improvements, or a plan for a general sewerage system; and all street improvements of a permanent nature should, thereafter, be made in conformity with the general plan.

In the case of sewers, after deciding upon the system to be adopted, whether a separate or combined system, by the aid of the topographical map the proper location of the main and lateral sewers can be decided upon, and no deviations should be made from said plan, except for very good reasons.

A question which will invariably confront the authorities of young cities which are about to make public improvements, is, "How shall the work be paid for?" Various cities have various methods. Some pay for the improvements by issuing tax receipts to the contractor, who is then supposed to collect the taxes for the improvement; others issue orders to the contractor, drawn upon a special fund created by assessment upon the property benefited, the orders, in some cases, drawing interest. Others, again, pay for the work in cash during the progress of, or upon the completion of, the work, the city realizing money for this purpose by the sale of its bonds running a certain number of years, and drawing a fixed rate of interest. This last method is the most economical for the city and its citizens, as it insures the contractor against loss

by failure on the part of some property owners to pay promptly their proportion of the cost of the improvement. The contractor will therefore not be required to put the amount of money into the work that he would were he compelled to wait for the collection of taxes before realizing anything from the job; and hence he will do the work cheaper. Not only this, but it gives a wider field for competition. It permits the contractor of limited capital to compete with the man who has a bank behind him. It gives better satisfaction to the persons who execute the work and to the persons who pay for it; to the persons who execute the work, because upon its completion and acceptance, they are paid all that is due them; and their interest therein ceases; to the persons who pay for the improvement, because they realize that they are paying far less than they would were the contractor paid in orders or tax receipts, thus compelling him to place his figures high enough to provide against loss and delay.

Where work is paid for otherwise than in cash, the party paying promptly is paying for the delinquency of his neighbor. For these and other reasons, improvements should be made upon a cash basis, and the adoption of such a system is recommended as being the most economical and satisfactory.

The question of the method of payment having been settled by the authorities, and the improvements decided upon, I shall discuss them under their respective heads, first, however, recommending the establishment of permanent marks or —

STREET MONUMENTS

of some imperishable material, by which to locate the street lines.

The particular location of these monuments is not so material, so long as a uniformity is observed in locating them with reference to the center or side lines of the streets.

A good plan is to plant a cast-iron post at the intersection of the center lines of all streets crossing one another. The size and shape of one form of post used by the writer, is shown in the accompanying sketch (Fig. 1). Weight, 15 pounds; cost, whatever you can get the casting done for, usually three or three and one-half cents per pound, including the drilling of a small hole in the cap, to mark the center.

The monuments are quickly and easily set. The point at which they are to be planted having been found, they are then driven by a heavy iron maul with wooden faces, care being taken to drive them straight, and the monument being kept to the line of each street by glancing over pins which have previously been set on the center lines. After driving the monument a few inches below the surface, measurements should be taken to the most permanent objects accessible, and recorded, in a convenient form for quick and easy reference, in a book kept for that purpose, and designated "Monument Book."

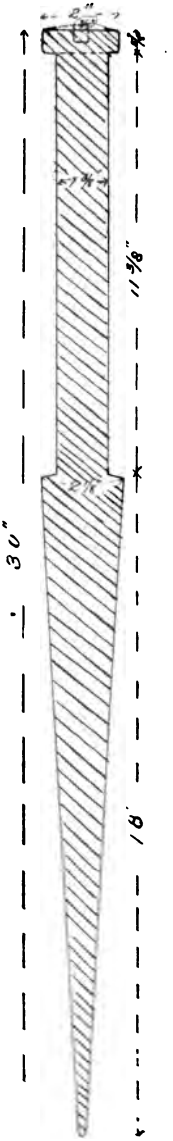

FIG 1

Street Monument

In recording the references, the writer uses an index book, indexing the east and west streets, and starting at the first street intersecting on the west, proceeding easterly, noting the streets in their order, to the east end of the street.

Each alternate page is ruled to five columns, leaving the intervening page blank for remarks; the last four columns on the first page are headed respectively "N. W.," "N. E.," "S. W.," "S. E.," and refer to the direction in which the reference to the monument was taken.

The sample page given herewith, explains this more clearly.

HOYT.	N. W.	N. E.	S. W.	S. E.	REMARKS.
Water.....	....	47.9 f. post	.....	62.8 to br'k chim.	.....
Washington	....	59.4 f. post	.....	39.0 lamp post..	.....
Franklin...	45.8	28.65 basin	30.05 basin	46.55 bld'g	.....
Cass	....	.....	.....	.....	.....

Explanation: Hoyt St., which appears at the head of ths page, is an east and west street, and the index street, Water St is the first street intersecting with it on the west. The reference to the monument at the center of Hoyt and Water Sts., are: —

Northeast, 47.9 to fence post.

Southeast, 62.8 to brick chimney.

The location of these monuments should also be shown on plats in the office, which should denote the distance between the monuments and the angles made by the intersecting streets.

With these preliminary remarks, I will proceed to the consideration of —

STREET IMPROVEMENTS.

It has been said that "water is the greatest enemy which a roadway has to contend with," and experience has fully demonstrated that fact.

From the construction of the most primitive kind of road, to that of the most improved modern pavement, that fact should be kept in view, and the cardinal principle to be applied to them all is DRAINAGE, both surface and sub-drainage.

Whatever the particular quality of improvement to be made to a street, the first duty of the engineer is to see that proper provisions are made for drainage.

Some soils, as those of a gravelly nature, provide in themselves for perfect sub-drainage, but those of a retentive nature, such as clay, should be thoroughly underdrained by means of tile drains; if sewers have been constructed in the streets to be improved, good outlets for the drains can be had in them; but if not, some other method must be resorted to.

The matter of grades for the gutters of paved streets is another important point to be considered. Sufficient grade should be given them to carry rapidly the surface water to the nearest sewer basin, or other outlet provided for taking care of such water. Generally speaking, the minimum grade should be 4 inches per 100 feet, but this will depend somewhat upon the character of the improvement. A gutter paved with large, smooth flag-stones, requires less grade than one paved with cobble stone, or some other material offering greater resistance to the flow of water. The proper form of cross-section should also be considered. As in the case of grade of gutter, so with the cross-section, the greater resistance offered by the surface of the pavement to the flow of the water, the greater the crown that should be given to the roadway.

Taking, for example, a street to be paved with cedar blocks, as probably that class of improvement is the one most generally adopted in the cities of Michigan, the minimum grade, then, for the gutters, should be 4 inches per 100 feet, and the crown for a 30-foot roadway, 7 inches.

The following sketch (Fig. 2) shows a half section of a 30-foot cedar-block pavement.

PLANS AND PROFILES for an improvement should give all needed information. The title should indicate clearly what it is intended to represent. The plan should show width of improvement, location of tile drains, sewers, man-holes, basins, culverts, and all other fixtures. Profiles should show grade of finished surface, grade of tile drains, profile of surface of ground on center line, and the profile of side lines might also be placed thereon to indicate the difference between the grade at any particular point and the surface of the adjoining property; and further, the scale should be shown, as it is sometimes inconvenient to pick up a plan from which the scale as well as the measurements, etc., have been omitted. A small table placed in one corner of the plan, containing the estimated quantities of the material to be used in the improvement, is also of use to those examining the plans, and saves the engineer an endless amount of trouble in answering questions.

Make the plans of a uniform width, as they can then be more conveniently filed in a case prepared for them. A width of 14 inches will be found convenient; this will give plenty of room for plan, profile, title, and other information. The plan and profile being made to a uniform scale of 40 feet horizontal to 4 vertical, by cutting to this width, 42-inch paper can be used without waste.

Indicate upon the plans all changes and additions, if any, made during construction, at the time they are made, as "delays are dangerous," and the alterations are apt to be forgotten after the lapse of a few weeks.

Properly label and index all plans, so that convenient reference may be had to them.

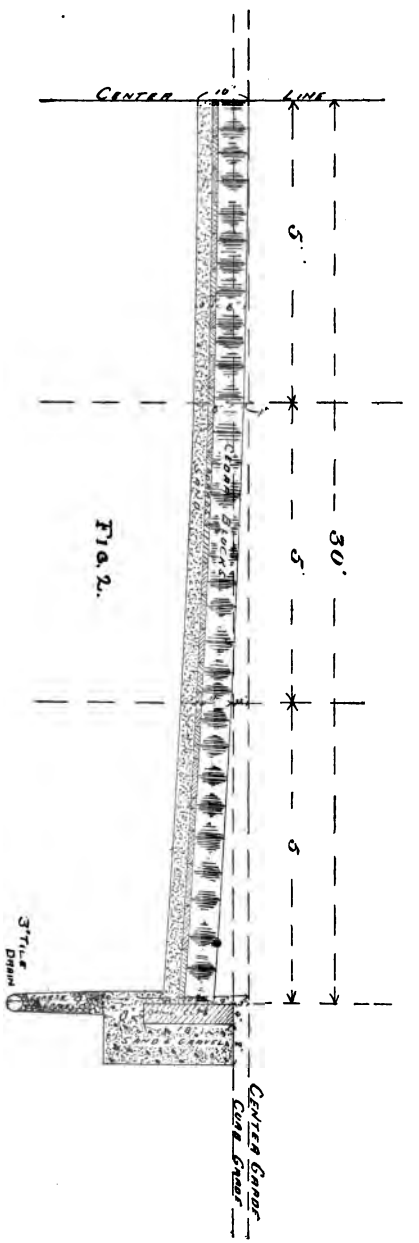

FIG. 2.

Half Section of 30ft. Cedar Block Pavement

THE SPECIFICATIONS should be carefully drawn; and, as much as possible, cover every point that is liable to arise during the construction of the work, so that the bill of extras may be reduced to the minimum.

They should be full enough to cover every contingency which can be forseen, and yet should be brief, concise, and to the point. A verbosity of language should be guarded against, as it leads to confusion, and makes the meaning less plain than would a shorter, clearer style. Describe plainly the method of construction, the kind and quality of the material to be used, and the method of measuring the work.

The specifications, in fact, should indicate in good, plain English just what is intended to be done, and nothing else.

CONSTRUCTION. — It behooves the engineer to see that proper and constant supervision is given to the work during its construction, as upon it depends largely the faithfulness with which the work is executed. For this purpose, a person properly qualified to judge of the merits of the material and workmanship, should be kept constantly upon the work, and he should receive his instructions from, and report direct to, the engineer in change.

In many municipalities, the power of appointing such an inspector lies with the Board of Aldermen, who usually make their appointments solely upon political grounds, and without reference to the qualifications of the persons to fill the positions to which they are appointed. This, of course, is wrong, and to the detriment of the corporation doing so. The power of appointing or discharging inspectors for public works should rest entirely with the engineer. In fact, after the contract has been let, the engineer should be given entire and unrestricted charge, and he alone should be held responsible for its faithful execution, and for the acts of his subordinates.

CARE AND MAINTENANCE OF STREETS. — In the case of earth streets, the road-bed should be kept well rounded up, and all ruts filled in so as to prevent the water from standing upon and saturating it. In some places the habit prevails of depositing rubbish, old cans, chips, and the rakings from the back yard, upon the streets. This should be prohibited by proper regulations. Ashes, especially coal ashes, are not detrimental to a road, but rather an improvement, as a road-bed formed of this material presents a hard surface, and is less liable to form ruts during wet weather. The side ditches should be constructed to a true and uniform grade, and kept free from rubbish, that the surface water may rapidly pass to the outlet provided for it.

It is frequently difficult in a flat, level country, with a clay subsoil, to prevent water from standing and stagnating in the street ditches. In such cases, tile drains placed two to three feet below the bottom of the ditches will overcome that difficulty, the bulk of the water passing over the surface to the outlet provided; the remain-

der, which usually remains to stagnate and pollute the healthfulness of the city, will find its way into the drains, thus leaving the ditch in a clean, sightly condition.

The benefits to be derived from tile drainage cannot be overestimated. The system not only greatly increases the healthfulness of the city by lowering the water line in the soil, but it drains and permits an earlier use of the road-bed in the spring of the year, by carrying off the water caused by rain storms and melting snow and ice, instead of permitting it to remain and accumulate. In constructing tile drains, care should be taken to provide good outlets, as upon this depend largely their efficiency.

The cost of these drains is not great, ordinarily three-inch tile is sufficient, where it is unnecessary to go far for an outlet. The tile can be laid at from 60 cents to $1.00 per rod; the manufacturer's list price is $17.00 per 1,000 feet. Usually, a discount from the price list, of 10 per cent and better can be secured, for the tile delivered on the line of the work. Three-inch tile, therefore, purchased at 10 per cent off list price, and laid for 75 cents per rod, will cost, complete, about $1.00 per rod, and a corporation cannot invest its money to better advantage than by the construction of tile drains.

PAVED STREETS should be kept clean and free from dirt. The frequency with which the streets should be cleaned, will be determined by the uses to which they are put. Cleaning may be done by days' labor or contract; either by hand, with brooms and shovels, or, in dry weather, with a street sweeper drawn by one or two horses, men and carts following behind the sweeper to take up and cart away the sweepings.

The impression a stranger receives upon his first visit to a city, depends very materially upon the appearance of its streets. A dirty street is not only unsightly, but unhealthy, as the accumulation of dust and dirt becomes saturated with the urine of horses, and other offensive matter, which is given off in noxious vapors during warm weather.

Ruts, holes, and depressions in a paved street, should be repaired as soon as discovered. The old adage of "a stitch in time" applies here with much force. A small hole or depression, left to take care of itself, will rapidly increase in size, until what could have been repaired for a few cents at first, will cost many times that amount to replace in good condition.

SEWERS. — Having had a general plan prepared, it only remains, as any particular sewer is ordered to be constructed, to prepare detailed plans and specifications for the work.

The remarks made relative to plans, profiles, and specifications for street improvements, will apply with equal force here. The plans should show, not only the location of the sewer, but all manholes, basins, connections, etc., and upon the completion of the sewer, all connections and branches should be located with refer

ence to some permanent object. A convenient way is to show upon the plan the distance between each branch or connection and a man-hole. Branches for private connections should be placed in the sewer every 25 or 30 feet apart. Construct catch basins where required, usually at each street corner, as the basins will then take the drainage from the gutters of both streets; but the location of the basins will depend somewhat upon the established street grades. The basins should be constructed of sufficient size to catch and retain the bulk of the dirt and rubbish washed in from the street. The basins used in East Saginaw are constructed of 8-inch brick walls, 3½ feet in diameter in the clear, and 8 feet in hight, with the outlet into the sewer, 4 feet above the bottom. The basins should be cleaned each year, after the spring rains, or oftener, if required.

In their construction, too much care cannot be taken to lay the sewer to a true and uniform grade; the joints of pipe sewers should be well cemented, and the inside of each length of pipe cleaned as soon as it is laid, otherwise obstructions will be formed by the cement which may be flushed through the joints, around which accumulations of sewage will form, and cause stoppages in the sewer.

For the inner ring of the invert of brick sewers, the hardest and smoothest bricks should be selected, and each joint neatly struck, so that as little resistance as possible may be offered to the free flow of the sewage.

All brick for sewers should be inspected, and the soft bricks, and bricks containing lime, rejected. In warm weather, the brick should be thoroughly saturated with water before being used. This will prevent the absorption by the brick, of the moisture from the mortar, and will also readily detect the presence of lime.

The mortar box should also be closely watched, especially if the contractor furnishes the cement. The best plan is for the city to furnish the cement, as it is then certain of securing a more uniform article, and there is no inducement for the contractor to mix poor mortar; but entire reliance should not be placed in the manufacturer. The cement should be tested before being used in the work. Short-time tests may be made which will indicate in a measure the value of the cement. Tests should be made for fineness and tensile strength. The report of the committee of the American Society of Civil Engineers, "on a uniform system for tests of cement," presented at the annual meeting of that society in 1885, and which may be found on page 388, Vol. 14, of the *Engineering News*, contains a fund of useful information for making these tests. Gillmore's "Limes, Hydraulic Cements, and Mortar," is also a valuable work on this subject.

In mixing the mortar, the proper proportion of cement and sand (usually 2 of sand to 1 of cement, when natural American hydraulic cement is used) should be placed in the mortar box, and the two thoroughly incorporated before the water is added, other-

wise the mortar will not be of uniform quality, some portions being richer in cement than others.

The mortar should be used in the work as it is mixed, thus securing the first set of the cement in the masonry.

If an inspector is necessary on street improvements, it is much more important to have one on sewer work, as sewers are buried beneath the surface of the earth, and defects in material and workmanship not detected before they are covered, are liable to remain undiscovered until some portion of the sewer fails, when a large expense is entailed in making repairs.

For an inspector of brick sewers, an intelligent, competent mason should be employed, as he understands "the tricks of the trade" better than one who has had no special training in that line, and can more readily detect bad workmanship.

In connecting lateral sewers with the mains, the laterals should be constructed on such a curve that the flow from the lateral will be discharged in the direction of the flow in the main, otherwise an eddy will be formed in the main sewer, which will invariably cause a deposit, and consequently an obstruction.

Construct man-holes at all changes in the alignment of the sewer, and as much oftener as may be found necessary for proper inspection and care. In the case of pipe sewers (12-inch and over), man-holes from 150 to 200 feet apart will usually be found sufficient; while for brick sewers, it will not be found necessary to place them as close together as for pipe sewers.

CARE AND MAINTENANCE.—Sewers should be kept as clean and free from deposits as possible. For this purpose, occasional flushings should be resorted to, or flush tanks, located at the head of the lateral sewers, and discharging at regular intervals.

The outlets, if discharging into running or other water, should be placed sufficiently above the normal level of the water to insure their free and unrestricted discharge. When a sewer starts below or partly below the surface, the capacity of the sewer is decreased by the area occupied by the backwater from the lake or river, and the sewage coming from above, and discharged into this slack backwater, is there deposited, and so much of the sewer occupied by this backwater then becomes an elongated cess-pool, and an active factor for the manufacture of sewer gas.

The growth of willow trees should not be permitted in the vicinity of sewers, public or private. Experience has demonstrated that the two cannot live harmoniously together. The roots from the trees, if unrestricted, will enter, and in a short time completely fill, the sewer. To illustrate: In the summer of 1885, a 12-inch pipe sewer was constructed in one of the streets of East Saginaw. The pipe was laid at a depth of about 11 feet, in a stiff yellow clay soil; on one side of the street grew three medium-sized willow trees. During the past season this sewer was removed, to make room for a large main sewer; and, upon taking

out the pipe of the old sewer, it was found that the roots from these trees had entered the pipe, and a mass of roots, somewhat resembling a piece of cocoanut matting, 75 feet in length, 2 inches thick, and 15 to 18 inches wide, was removed from the sewer.

Many other instances of a like nature have come under the observation of the writer. In some cases, the sewers have been completely filled with the roots, necessitating the removal of the sewer, and the destruction of the trees.

In conclusion, it may be well to offer a few general —

REMARKS.

The quality of the improvements to be made in the streets of a young city, will depend very much upon its natural resources, and the first improvements will be made with a view of reducing the first cost to the minimum. The city with age and population, will demand something better, more durable, and of necessity more costly, than that first adopted; and in time will probably go through the whole category of roads, from a cheap gravel or planked road to that of one of block stone or asphaltum.

Michigan having such an abundance of timber suitable for pavements, naturally that material is used very extensively for the improvement of the streets of its cities. Cedar seems to be the timber now most generally adopted for the better class of wooden pavements, but owing to its lack of durability (which is also true of any wood pavement), it is really one of the most costly which can be constructed.

Many of the eastern cities, notably Washington, D. C., have practically abandoned the use of wood, and are adopting other materials.

Washington, which previous to 1879 had over thirty-four miles of wooden block pavements, costing over $4,000,000, has quite abandoned its use; and has now almost entirely replaced the old pavements with stone or asphaltum.

Sanitarists protest strongly against the use of wood for paving, as being injurious to health, and with very good reason; wood being of such an absorbent nature, readily retains the liquid filth from the street, to be given off, during warm weather, in odors offensive both to the senses and to health.

But the fact is apparent that, so long as wooden pavements can be constructed so much more cheaply than those of a more durable and less objectionable kind, just so long will wood be used, yet in the construction of the pavements and the selection of the material, care should be taken to make them as durable as possible.

Cedar, as most generally used, is stripped of its bark, cut into suitable lengths, and placed upon the foundation prepared to receive it, retaining all the sap wood, the portion quickest to decay, and the portion which most readily absorbs the filth of the street. Remove the sap, and you remove the most objectionable part of the wood.

Experience has shown that the life of a pavement, constructed of *sapless* cedar blocks, is longer, and that the surface wears smoother and more uniform, than when the sap is left on; for the sap wood being first to decay, hastens the destruction of the rest of the block. Then again: the blows from the wheels of passing vehicles wear away the sap more rapidly than any other part of the block, thus forming depressions in which to hold the water and wash of the street, to be absorbed by the blocks, and giving to the whole a rough, uneven surface over which to ride.

It was the intention of the writer to dwell somewhat upon matters pertaining to sewerage and other municipal works; but this paper has already exceeded the limits originally assigned to it. One word more, however, to the engineers here assembled.

Remember, our calling is not only of an executive nature, but it is more exalted than that. If we do not administer directly to the moral welfare of our fellow-men, we should at least contribute to their physical well-being. We can do this by example as well as by precept. Convince him of the unsanitary conditions of his surroundings, and indicate the remedy; show him wherein the pollution of his supply of water for domestic uses lies, and how it leads to physical debility and death. By continuous and untiring efforts in the right direction, much can be done to improve the condition of those who live in our respective communities.

A man has never attained to his most exalted position until he ceases to be selfish, and works for the improvement and elevation of others.

JOHN J. GRANVILLE.

Prof. Carpenter. — "I found at Memphis that their sewer system has not a good reputation at home. They have flush tanks at the heads of the small laterals. They use the Fields flush tank, which is a simple affair, consisting of a siphon arranged at the side of the vessel, the water going out with a rush. They report it as somewhat uncertain in its action. The siphon does not always act, so that the water, instead of going out with a rush, goes out at the same rate that it comes in. The city engineer reports that the use of a tilting trap, and an inside lip which reduces the size of the siphon, will cause it to act."

Mr. Appleton. — "Is there a deadener to this trap? They used the tilting traps in London years ago, and the noise of them was a great nuisance."

Prof. Carpenter. — "It is not needed, being below the street."

Mr. Appleton. — "There is a trap in this city having a movable bottom, which I put in several years ago, that has worked well, and never failed. It is not automatic, nor intended to act as an intermittent flushing trap. We do not put in a brick basin, because cement pipe is cheaper, and just as good. It is one thing that a cement pipe is good for."

Prof. Carpenter. — "Has Mr. Granville had any experience in the use of brick for pavement?"

Mr. Granville.— "I have not. I have received reports from Ohio engineers in regard to it, and samples of the brick used. It was not a vitrified brick. The trouble with brick pavements seems to be in the proper selection of the brick, to get them of a uniform quality. Some engineers retain a percentage until the pavement has been tested by one winter's frost."

Mr. Appleton — "If ground slate is mixed with clay, it makes it perfectly durable, but the trouble is in a false economy which will not pay for the best."

Col. Muenscher. — "Some cities require a good deal of blue clay in the brick."

Mr. Appleton. — "There must be a good deal of sand in a good brick, but it must also contain other material."

Prof. Carpenter. — "I saw a good many samples of brick at the brick-makers' convention. I think we have no clay in Michigan suitable for such brick. They must be very hard, dense, and not vitrified. A vitrified brick is not so strong as one which is not. In Cleveland, brick is as cheap as wood, and it can be laid down in Detroit as cheap. They have good brick in Ohio."

Mr. Watkins. — "In a sanitary point of view, is not the vitrified brick the best, being less absorbent?"

Prof. Carpenter. — "I do not know as there is any difference."

President Steele. — "I think we had better drop this part of the discussion here. We shall have the topic up later, in the paper from Prof. Greene. Have we anything in regard to other kinds of pavement, say of wood? In Traverse City, the streets are underlaid with sand. I don't know how deep. We have a pavement there which is a compromise between a stone pavement and a gravel road. The gravel packs very hard, and is very successful. We have plenty of cedar right at hand."

A. L. Reed. — "What sort of foundation is best for a block pavement?"

Mr. Granville. — "It is best to put boards under blocks. The first block pavement we had in East Saginaw was put down without boards, and the blocks went down unevenly. We roll the streets with a ten-ton roller, put on three inches of sand, and then cover with inch boards."

Pres. Steele. — "At Grand Rapids, they have cedar blocks on a gravel bed well rammed down, and covered with nothing but gravel well rammed. They have excellent drainage That may have a decided effect on the durability of the pavement, and speaking of that, if you want a durable plank, take one that has been in the mortar bed."

Col. Muenscher. — "This system was introduced into Grand Rapids sixteen years ago, when I was city engineer, and I believe it is the best there is. You must have a good foundation. Excavate a foot in depth, and fill it with gravel, not sand. The blocks in this foundation have stood ten years without displace-

ment. Leave the boards out when you have a clay bottom. The water runs through, and will rot the boards first. Then, too, the boards are always being cut and taken up, to make connections with gas, water, and sewer pipes, and can never be put back in good condition."

Mr. Granville. — "Right here is a point for criticism. In making sewer, gas, and water connections, the earth is softened. If boards are not put in, the blocks will go down. The boards will to a certain extent prevent that. If the blocks are well filled between with fine gravel tamped in, you have almost hermetically sealed the pavement, so that no water will go through. In East Saginaw we try to reduce the evils of taking up the pavement, by requiring people to make their connections the fall of the year preceding the paving of the street. If they wish to do it after the street has been paved, they are charged $25, to pay for the permanent damage to the pavement. We thus do not have much disturbance of the pavement. We take up a 16-foot section at a time, and never allow a board to be cut."

FREIGHT YARDS AND SIDINGS.

In looking over the reports of former meetings of this Society, I find several able and exhaustive articles on the location and construction of railways. There is, however, among others, one item which has been pretty much overlooked; that is, sidings and freight yards. They are not much thought of in the location of railways, and railway companies usually think that after a road is located and the main track laid, they can dispense with the services of most of their engineers; so the work is left to the trackmen, and the engineers are off to new construction. Consequently many of them have no experience in track work, and if by chance they are called upon to do such work, they are likely to commit blunders. This is one reason trackmen often have a contempt for engineer's stakes.

The locating engineer ought to have in mind the places where side tracks are likely to be put in, and then make the grades at such places as nearly level as possible. Serious accidents accompanied by loss of life have occurred from cars being started by the wind, and running out on the main track. This can be prevented by the stop-blocks in use on some roads, provided there is no neglect to put the blocks in place.

There should be as few switches as possible in the main track. Let the yard be developed from the side tracks.

There ought to be at least some attempt at uniformity in the laying out of the freight yards of any particular road. If there is a regularly organized engineer department, and the road master's

department is, as it always ought to be, subservient to the engineer department, there will be no difficulty in securing uniformity of plan.

Of course, yards will vary in the number and length of tracks, to suit local needs. This uniformity will conduce largely to economy and ease in handling traffic. If there is a plan determined upon before the yard is begun, the discovery will not be made that the freight house is located where there ought to be tracks, and that there are tracks where the wagon road ought to be.

There ought to be no open culverts or cattle-guards in the vicinity of freight yards or sidings.

Railway companies should care for the comfort and safety of their employees, even if they are not liable for damages.

The yards should be well lighted and well drained. Yard work is disagreeable and dangerous enough without wading ankle deep in mud or slush.

The blocks which are bolted in the throats of frogs, in the mouths of switches, and in the ends of guard rails, are useful in preventing men from catching their feet, and being thrown down and run over.

Some roads use a switch like the "Wharton" in the main line, and the split switch in the yard. Others use the common stub switch all around. Whichever is decided upon, let all the yards be similar, and brakemen will sooner learn the road, and in case of a strike, new men will the quicker become available. In staking out a siding or yard track, let not the engineer be too fussy. Now-a-days frogs are numbered according to the ratio of width to length, as 1 in 6, 1 in 10, commonly called No. 6 or No. 10. Methods are given in the various engineer's pocket-books for computing the distance from mouth of switch to point of frog. Suppose the engineer has found the distance to the end of the frog to be 58.97 feet. Let him stake it out 58 or 60 feet, for no track-man will cut a rail to humor his odd hundredths.

The remark is applicable which I once heard an eminent engineer make in reference to transit work. He said, "It requires a good deal of ability to know when to slight transit work." So I say it requires some judgment to know when to comform strictly to theoretical measurements.

In staking out a freight yard, the tracks are indicated by stakes on the center line with a tack in each. In large yards, to prevent confusion, the stakes may be painted a different color for each track.

The mouth of switch is indicated by a stake marked "M. S.," and the point of frog, by a stake marked "P. F."

The turnout curve may begin either at the mouth of the switch, or the heel. In the latter case, one end of the switch rails is spiked fast, and the curvature obtained by the movement of the switch rails. This makes the switch turn harder. It also changes

the "lead," or distance from mouth of switch to point of frog. In case it is required to turn out from a curve either inside or outside, the pocket-books give intricate formulas, but the following method, due to the late Charles H. Fisher, Chief Engineer of the New York Central, will answer as well:—

It has been shown that for practical purposes, the lead is nearly enough the same on straight lines as on curves. Now suppose that we wish to turn out from the inside of a 4° curve with a switch angle of 1° 20′, and a frog angle of 7° 10′. The lead, as may be found from the tables, or by computation, is about 58 feet. A 4° curve turns 2° 19′ in 58 feet. Adding the frog angle, 7° 10′, we have a total angle of 9° 29′. To meet this, we have the switch angle 1° 20′, and the curvature of the turnout. Subtracting the switch angle, leaves 8° 9′ to be turned by the turnout curve in 58 feet. This gives about a 14° curve.

In these days, when railways find it necessary to practice every economy, let not the freight yards be overlooked. It is just as easy and just as cheap, if the matter be taken in hand in time, to have a good, safe yard, as to have a poor, dangerous one.

O. C. GILLETTE.

Pres. Steele. — "I am glad to hear this paper from Mr. Gillette, and that he has given us in it a practical rule to work by."

Col. Muenscher. — "Very serious accidents sometimes occur from cars being blown from the side track to the main track. A simple and effectual preventative is to make the side track six inches lower than the main track. No wind can then blow a car from the side to the main track."

EVIDENCE OF FLOWAGE.

Mr. President and Gentlemen: —

THE surveyor is left to his own resources to a great extent in determining questions of flowage, and I shall not attempt to treat the subject here, as I am not the right man to do it, and shall be content simply to bring up the subject for discussion. To this end, I will give, briefly, the circumstances of a recent case.

By rights given under title of a deed, a dam was constructed entirely across the Kalamazoo River. The hight to which the right would raise the water, was definitely fixed by permanent bench marks on stone and tree. For a long term of years, this condition of affairs remained *in statu quo.* At last the requirements of civilization and more factories called for about two more feet of water, and with flash-boards that amount was easily obtained, often raising the water thirty inches above the prescribed right. The proof of these facts was permanent, clear, and undisputed. The

point denied was that although the water was raised unduly, it had no effect on fifty acres of land lying half a mile and more up the river.

The natural width of water was ten or fifteen rods. Above the dam, the water now spreads out to a width of twenty rods. The complaint of overflowed land commenced half a mile above the dam, and at this half-mile point, the water is six inches higher than at the bench mark, which is about eight rods above the dam.

An unmeasured line of levels was run from the bench mark along the river to the land, making there a bench mark at the same level as the old bench mark. The line was then extended and measured along the river and the land about 28 chains, and at suitable and convenient intervals, as many stations were made and lettered as was thought necessary. In this case, only six were made for fifty acres, as the land was not very uneven. From these six stations, cross lines were run due south; the river runs west, and levels were taken every eight rods. All these cross lines, that were needed to reckon the acres of wet land, were measured. The rest were paced, and with a few bench marks at H. I., this completed the survey.

Profiles and a map were made with contour lines of the land, showing, by small circles, the exact position of all the stations; in red ink, the hight of each station above the ice, and in green ink, the hight above the water of the river, when the water should be at its proper level, in this case, the hight of the dam, the dam being correct. Now comes in the question, What is a proper level at the land, under the circumstances? Is it the level of the dam? or should six inches be added to that level? or should still more be added? In other words, how much will water pile up under these conditions, and how much under other and dissimilar conditions?

A very important and separate set of river notes was kept, just as important to the purpose of survey, as the survey itself. The main purpose of the survey is to show the connection (if any) between the overflowed and wet condition of the land, and the raising of the dam with flash-boards. These notes show the exact position of the surface of the water, very early in the morning, of each morning, at the dam, and at the land, before the mills are started; also the surface at night, of each night, at the dam and at the land. The first morning a thin ice stuck to everything along the river, and remained two days. The water drew down three inches, at noon of the first day, at the dam, and two and one-fourth inches at the land. But the wind blew strong that day from the west, and up the river, and raised the water three-fourths of an inch at the land, because the water went down eighteen inches the next day at the land and dam alike. The second morning a heavy coat of ice formed one inch thick and about two inches lower than the first morning, two inches lower

at the dam and two inches lower at the land. At the latter place, ice formed entirely across the river, but not above there. Thermometer, 22°. At night of the second day, the water had gone down eighteen inches at the land, and just eighteen at the dam. The wind was now reversed.

Of course it is the peculiar province of the court and jury to say that these facts mean nothing, and show no relation between the dam and land, and the judge generally takes the trouble to point out to the jury that the Supreme Court of the State has decided that a surveyor's evidence is not the evidence of an expert, and that they need not give it any more weight than the evidence of anybody else. Nevertheless, these facts should all be noted fully, and written out with care, mapped, and submitted.

Ice does not always form just when you want it to, nor at all times of the year. But stakes can be driven at the dam and at the land, and water marks be made by pressing in tacks at the surface, at the times of high and low water, and as extended a record kept as possible and as the time will allow. Indeed, the date and hour can be written on the stake itself, and against each tack. Better still, at the land notches may be cut on saplings growing in the water. These notches may be referred to, in months and years to come, with confidence, when it shall be necessary to take more evidence, or to verify what has already been done, knowing that they cannot be driven down or raised by ice.

These water-sprouts and saplings present a new and important branch of evidence of their own; namely, that they never began life one or two feet under water, or even six inches. Hence the map can show a few places where sprouts are growing in the water, and show its hight above their union with the stump. This measure must be taken, in all cases, at the top of that union, as the growth is mostly on the lower side. There can also be marked upon the map the position of a few stumps standing in the water (if there are such), giving the size and kind of timber.

Another equally conclusive source of evidence of the facts required by the survey, may be given under the following conditions: When there are even a *few* spots of sand or fine cultivated loam along the edges of the high-water line, this line will be nicely marked, sometimes in one way, sometimes in another. Close and accurate marking will be found where a light dash of rain or snow or hail has printed all the exposed surface, while the sand, covered with water, will be smooth; and when the mill owners see the surveying party preparing for business, they are sure to draw off the water as fast as possible. At least such is always the talk, and the facts seem to sustain it. Then the surveyor can read, as he walks, the exact position of the high-water line, and as the water recedes, compare its positions, above and below. This printed line is far better than the water line itself, as the latter is continually changing, and is likely to

introduce an element of error, while the printed line will not move until covered with water, and will then stop again at some particular grade. E. STRONG.

Prof. Carpenter. — "There is one question raised in that paper that has been discussed a great deal before this Society, as to what constitutes the hight of a dam. Probably all the surveyors of Lansing have made extensive surveys to determine that question with reference to the dam at North Lansing. The Court refused to answer the question as to what constitutes the true hight of a dam, and decided the case entirely on the ground that the dam had been raised from its original hight, and must come down again, without regard to the actual hight of the dam. We do not know yet whether the head of water is to be measured from water below the dam to water above, or from the ground below the dam to the top of the dam, or in what way the true hight should be determined."

Mr. Hodgman. — "The point made in this paper, as I understand it, is in relation to fixed bench marks on the bank of the stream."

Mr. Appleton. — "Is it not rather how much the standing wave is? We know that this wave varies in different conditions."

Mr. Hodgman. — "The question raised, it seems to me, is, If we raise a dam a certain distance, will it raise the water in the stream above level with the dam, or will it raise it higher than the dam, and if higher, how much at different points in the stream above, and how will this affect the flowage?"

Mr. Appleton. — "It will do that. In the case here, the water was raised enough above the dam to be readily determined."

Mr. Watkins. — "Did you determine the hight with reference to certain fixed marks?"

Mr. Strong. — "Yes, sir."

Mr. Watkins. — "The point was once raised in this Society whether a stump is reliable for a bench mark, and it was decided that stumps cannot be depended on."

Mr. Strong. — "That might be true, but I think it has been sufficiently well determined that a tree will not vary in its hight, but each part retain its original level. This has been demonstrated by a large number of experiments. The bench marks in this case were made upon trees and boulders, and stakes were also driven into the water in some places to a certain depth below the surface, so that even if some of the bench marks were moved or destroyed, we would still have something left."

Prof. Carpenter. — "In the case of the North Lansing dam, I made the survey when the water was very high, and Mr. Appleton, when the water was very low. The standing wave from the dam, as I measured it, was reduced as you neared the head of the dam. I think when Mr. Appleton had two inches of high water, I had nearly two feet."

Mr. Appleton. — "The standing wave varies with varying conditions of the water, but I think we pretty well settled it."

Mr. Strong. — "Did you take into account the wind?"

Prof. Carpenter. — "This river is thoroughly protected from the wind."

Mr. Appleton. — "About four miles of it is through the woods."

Mr. Watkins. — "I know a dam is a dam with me."

President. — "I don't find it so. A farmer who thought he was terribly injured by a dam in Leelanaw County, commenced suit to take away a dam below him. The gentleman who owned the grist-mill that was situated on the stream, had to suspend operations, and went to a good deal of expense and trouble to find out the actual fall. The farmer claimed that the dam had raised the water in the lake, and had caused it to overflow the adjoining lands which he owned in that vicinity, and he was making every effort to abate the nuisance. It was tried in the Justice Court, and next in the Circuit Court for the county of Leelanaw, and I was called upon to take some observations and levels about there on the part of the owners of the mill. I found the hight of the standing wave very much to the astonishment of the opposing counsel, who could not see how water could be anything but level, or how a dam could actually raise the water above it, although, as I told them, it could be easily detected with the levels. But the point which secured the defendant's case was that happily there were four government meandering posts on that lake, and they were witnessed, and those witnesses were all perfect, and when I went there with a boat, I found everything all right, and that the original stakes which the government surveyors put in the swamp were perfect, although they were thirty or forty years old then, and they were exactly where they ought to be in every case. They found that the survey which I had made showed the water in the lake at the same hight as it was shown to be by the government surveyor, or a little lower, hence how could the dam have caused the rise of the water? The fact was that the rise in the stream had been caused by a large number of springs on the farm owned by the complainant, so that he really was the party to blame for the overflow, and not the defendant's dam. The point won the case. Of course, the leveling is very nice, and it was something they could not get around."

TESTS OF MICHIGAN WOODS.

THE last two winters I have had considerable opportunity to become acquainted with the methods of testing, first at Cornell University, and since at the College. The machine we have is arranged to take material up to a certain size, two and a half inches square or less, and the testing capacity is 50,000 pounds. The power is applied by means of a hydraulic press. This machine is arranged, as most of them are, so that we can test lengthwise, either in tension or in compression, and crosswise or transversely. Now, in testing material, we want to get the breaking weight and the elastic limit. There will be a certain stretch, up to which point it will go back to its original form, or nearly so. This is the elastic limit. Just where this elastic limit is, is really more important to know and to find out in our investigation, than how much it will take to break it. It is necessary, then, in order to determine that, to have some instruments by which we can measure the stretch of it, or how much compression it will stand in pushing it together. I have for this purpose arranged two little points which I place on two collars, between which I put a micrometer of the Brown & Sharpe pattern, and in this way I can measure the elongation. Now so long as this elongation is uniform, we are within our elastic limit; and so long as it keeps within the elastic limit, it will go back, or nearly back, to its original form. But a time comes presently when the stretch becomes greater, and instead of being one-thousandth of an inch, it increases to from two to sixty thousandths of an inch, and more. You will notice in the specimens that I have here that some of them look as though they had been tapered off, when actually they were just the same size before testing.

Here is a piece of tool steel about one-fifth of a square inch in area, which took actually 33,000 pounds to pull apart, being the strongest piece of steel I have ever tested. Here are some specimens of a bronze which is considered to contain about 5 per cent of aluminum, and here is a piece of common bronze. If you will look at this specimen, you will see the effect of the pulling. You will notice that this is drawn out of shape. Sometimes the piece breaks in a very queer way, and in pulling it out the tension causes it to open up in several places. Now, in testing woods, this much we have found out — and probably it is a well-known fact to all that are using woods — we can never get a fair tensile test of wood, on account of its being almost sure to give you a splitting break, rather than a square cross break. Woods are not fit materials to be used in places where tension is required.

For compression and transverse strains, wood works very well, and the results we get with our testing machine are very satisfactory. I have tested forty or fifty different kinds of wood. Hard

maple runs up the highest in transverse strain, having reached 18,924 pounds to the square inch. Among some other specimens I have tested, is white pine, which ran as high as 8,000 pounds, some specimens running a little below and some above. In some other reports I have the locust, as running highest, 17,000 to 19,000 pounds.

Wood is generally used in a frame or truss, either as a beam, or as a post or pillar. In the first case the effect of the load is to bend the beam, and finally to break it, where most bent, or close to the points of supports. The power of the beam to carry such a load, we term its transverse strength, limiting the term usually to the bending only, and using the term transverse shear when we refer to the strain next to the points of support.

Where wood is used as a pillar, the effect of the load is to compress or shorten it; if the pillar is less than about ten diameters long, the effect is generally to crush it, either by a wedge flying out from one or more sides, or by the doubling up of the fibers of the post. When the pillar is long with respect to its diameter, the effect of the load is to bend it, often into a complicated form. The theory of this last case is not a simple one, although within the elastic limit it seems to agree well with experiment.

Wood is sometimes used as a tie rod, in which case the strain tends to pull the fibers apart, or to lengthen the rod. Wood is poorly adapted for such strains, since the effect of cross-grain or knots or any defect whatever would be more seriously felt here than in the other cases. A large and uncertain excess of strength would in this case be needed.

Wood is sometimes used as a mere bearing block, in which case the effect is the same as a very short pillar.

The theory of action of forces on materials is treated at length in various works on the strength of materials, and can be studied exhaustively in such books. For the convenience of those who may desire to look the subject up thoroughly, I will mention a few works published by Wiley, as follows: Burr, "Strength and Resistance of Materials;" Lanza, "Applied Mechanics;" Church, "Mechanics of Materials;" Merriman, "Mechanics of Materials;" Wood, "Strength of Materials;" Thurston, "Materials of Engineering." The work by Burr is especially full of information.

For the convenience of those who may not have access to any of the works mentioned, I give a few formulas for the simplest cases. These formulas, probably, strictly speaking, will apply only when the load is within the elastic limit, but the results are in most cases nearly correct up to the breaking point. It is customary to figure the formula as correct up to the breaking point, and then take loads one-fourth or one-fifth the amounts given, as safe loads. By the elastic limit is meant that load which produces the first permanent deformation in the shape; it varies all the way from one-fourth to nine-tenths the breaking load, in different materials. In

testing the strength of materials, it is important to locate the elastic limit; the method of doing this is as follows: equal increments of load are added, and the resulting change of form is measured. So long as equal increments of load produce uniform deformation, the elastic limit has not been passed. When the deformation increases at a greater rate for the same increase of load, it is assumed that the elastic limit has been passed. This involves a very minute and accurate measurement, as the deformation in all cases is small, and a small error may make a considerable difference in the result. The approximation location of the critical point is the best that can be done.

Many experimenters do not believe in the existence of an elastic limit, but the discussion of that point does not come within the limits of my paper. The coefficient of elasticity is obtained by dividing the load per unit of area by the stretch per unit of length, at any point within the elastic limit. It is greater for the stiffer materials.

The following formulas represent the simple cases of breaking:—

For Tension:

$P = FS$

P = breaking load.
F = coefficient for Tension.
S = area square inches of cross section.

For Crushing:

$P = CS$

C = coefficient for crushing.
S = area square inches of cross section.

For Compression — Long rectangular columns square ends of wood:

$$P = \frac{F' S}{1 + \frac{1}{250}\frac{h^2}{l^2}}$$

F' = coefficient for compression long columns.
S = area in square inches.
l = length in inches.
h = least dimension in inches.

For Transverse — Beam supported both ends, load at center, Rectangular beam:

$$P = \frac{2}{3}\frac{b h^2}{l} T$$

h = depth in inches.
b = breadth in "
l = length " "
T = coefficient for transverse breaking.
P = breaking load.

For Shear:

$P = F' S$ in which F' equals the coefficient for shearing.

In all the above formulas:

P = breaking load.
S = area of cross section.
l = the length in inches.

The following results are in common use:—

TABLE OF COEFFICIENTS OF STRENGTH OF WOOD — FROM CHURCH'S MECHANICS OF MATERIALS.

	Elasticity.	Strength at Elastic Limit.	Strength at Breaking Point.
Tension	200000 to 2000000	3000 to 19000	6000 to 28000
Compression	.....	.....	.....
Short Blocks	350000 to 2000000	.....	2000 to 10000
Compression	.....	.....	.....
Long Pillars	.....	.....	7200 .....
Transverse	1000000 to 3000000	1000 to ?....	4000 to 20000
Shear { across grain	.....	.....	1500 to 8000
Shear { with "			500 to 1200

The tensile strength of woods is difficult to obtain experimentally, because of the liability of breakage by splitting instead of pulling the grain fairly apart. Any imperfection is especially manifest in this kind of strain.

I have made but few tests to ascertain the tensile strength of wood, and these gave results considerably less than the values tabulated in our works on strength of materials. As showing the method of making these tests, I submit the log of one test complete: —

TEST OF SEASONED HARD MAPLE 8.67 INCHES LONG, SQUARE CROSS SECTION 7-INCH AREA.

Load Shown by Testing Machine.	Micrometer Reading inches.	Stretch in inches.	Load per square inch.	Coefficient Elasticity.	Remarks.
0	0.486	0			
1000	0.488	0.0025	1428		
2000	0.490	0.0025	2857		
3000	0.494	0.0035	4285		
4000	0.498	0.0040	5999		
5000	0.503	0.0050	7143	3.753320	Near the Elastic Limit.
5500	0.511	0.0080	7857		
6000	0.5140	0.0080	8571		
6500	Rupture.		9285		Split and sq. break exposing 6 sq. inches.

The following are some values found for other woods : —

TESTS OF WOOD IN TENSION — SUMMARY OF RESULTS.

Kind of Wood.	Approximate Elastic Limit.	Breaking Strength.	Coefficient Elasticity.	Length inches.	Area sq. inches.	Remarks.
White Pine.....	2685	6712.3	671220	13.2	0.739	Round poor break.
Swamp Oak... ..	3846	7692	1797663	7.0	0.526	
Black Walnut....	2978	6400	1240000	6.0	0.503	
Hard Maple.....	5999	9285	3753320	8.67	0.700	

LOG OF TRANSVERSE TEST OF SUGAR MAPLE.

Load applied at center 24 inches long, 2.9 inches deep, .86 inches thick.

Load Applied.	Reading of Micrometer inches	Total deflection at center inches.	Coefficient of Strain per square inch.	Coefficient of Elasticity.	Deflection per 100 lbs. inches.	Remarks.
0	0.921					Well seasoned specimen Rectangular cross section.
500	0.844	.077	2490		.017	
800	0.811	.110	3984	1199000	.011	
1000	0.781	.140	4980		.015	
1200	0.760	.161	5976		.0095	
1400	0.734	.187	6972		.013	
1600	.698	.223	7968		.018	
1800	.683	.238	8964	1246000	.0075	
2000	.659	.262	9960		.012	
2200	.624	.297	10856		.0175	
2400	.597	.324	11952		.0235	
2600	.558	.363	12948		.0195	
2800	.525	.396	13944		.0165	
3000	.480	.441	14940		.0225	
3200	.427	.494	15936		.0265	
3400	.367	.554	16932		.030	
3600	.284	.637	17928		.0415	
3710	Broke.			18924		

It is to be noticed that the deflection, although somewhat irregular, remains about constant, until the load is greater than

2,000 pounds, in which case the coefficient is 9,960 pounds per square inch.

I found accidentally that a very complete determination of the transverse strength, and various other properties of woods, had been made for the tenth census reports of the United States. These determinations were made for Prof Seargent by Stephen P. Sharples, of Cambridge, Mass.

In the results as published, all dimensions and results are expressed in French measures. The specimens for transverse strength are uniformly of a square cross section, each side being 4 centimeters. In breaking, the specimens were vertical and the force applied horizontally. For crushing, the blocks were uniformly 32 centimeters high and 4 centimeters square.

The specimens were all thoroughly air dried, and the weight in pounds per cubic foot is given.

The fuel value was obtained by actual combustion with an analysis of the resultant products; the results are expressed with an arbitrary series of numbers, the fuel value being in proportion to the numbers.

The number of specimens of each kind varied from five to fifteen.

Thinking these results might be useful if put in an available form, I reduced the average result of each species to English measures, and have arranged in the following table the properties given for all the native specimens known to grow in our own State. These results are so full and complete as to make it entirely needless to publish the meager results of my own tests. I give, however, the log of one test for transverse strength, to show the method of testing, rather than to give information as to the results.

PROF. R. C. CARPENTER.

Mr. Watkins. — "How do you find swamp oak, as compared with other woods?"

Prof. Carpenter. — "Swamp oak is not as strong as hard maple. It runs, I believe, about 14,000 to 15,000 pounds per square inch."

Mr. Watkins. — "Among mill men I believe it is considered the stiffest timber for shafting."

FROM CENSUS REPORTS — REDUCED TO ENGLISH MEASURES.

Woods of Michigan.		Weight per cubic foot, pounds.	Approximate fuel value.	Coefficients of			
Botanical Name.	Common Name.			Elasticity.	Ultimate Transverse.	Longitudinal Crushing. Pounds per square inch, 8 diameters high.	Resistance to Indentation. $\frac{1}{10}$ in. depth per sq. inch.
Liriodendron Tulipifera	White Wood — Tulip Tree	26.36	63.26	1283000	6797	5520	1120
Asimina Triloba	Paw Paw	24 74	39.61	663000	5560	3615	900
Tilia Americana	Basswood Linden	28.20	45.00	1183000	8374	4875	890
Xanthoxylum (Colden) Americanum	Prickley Ash	35 23	50.15	1035000	9115	6175	1130
Acer Saccharinum	Sugar Maple — Rock Maple	43.08	68.75	2064000	16225	8670	3400
Acer Nigrum	Black Sugar Maple	43.09	68.66	1043000	13679	7470	3500
Acer Dasycarpum	Silver or White Maple	32.84	52.52	1560000	14590	6650	1540
Acer Rubrum	Red or Soft Maple	38.50	61.65	1335000	11634	6400	1360
Nigundium Aceroides	Box Elder — Ash-leaved Maple	26.97	47.95	800000	7522	4370	1480
Rhus Copallina	Dwarf Sumach	32.86	52.42	1030000	9427	5200	1465
Rhus Venenata	Poison Sumach	27.31	77.28	1485000	9314	7960	2800
Cercis Canadensis	Redbush — Judas Tree	39.65	63.18	985000	10689	6460	2460
Gymnocladus Canadensis	Kentucky Coffee Tree	43.21	68.88	1485000	10977	5520	2170
Gleditschia Triacanthus	Honey Locust	42.00	66.86	1535000	13124	6950	2240
" Monosperma	Common Locust	45.76	72.89	1670000	17087	8150	3790
Prunus Americana	Wild Plum	44.96	72.02	1173000	9460	8200	2900
" Serotina	Wild Cherry	36.28	58.14	119400	11160	7560	2750
Pyrus Coronaria	Wild Crab Apple	43.92	70.11	893000	6630	5775	3400
Amelanchier Canadensis	June or Service Berry	48.85	77.95	1695000	16000	9430	3860
Cornus Florida	Flowering Dogwood	53.81	80.98	1153000	12790	7360	4250
Nyssa Multiflora	Pepperidge — Black or Sour Gum	39.59	63.66	1150000	11630	6470	2640
Fraxinius Americana	White Ash	40.77	65.16	1422000	10520	6460	2260
" Pubescens	Red or Downy Ash	38.96	62.35	1134000	9840	6050	2770
" Quadrangulata	Blue Ash	46.78	74.50	1090000	9120	6870	2750
" Sambucifolia	Black Ash	39.37	62.72	1090000	11300	5770	2630
Sassafras Officinale	Sassafras	31.42	50.38	709000	5510	5250	1770

Ulmus Fulva	Slippery Elm	43.35	69.77	1340000	13160	7520	1950
" Americana	American or White Elm	40.54	64.54	1070000	11200	6220	2530
" Racemosa	Rock or Cork Elm	45.26	72.20	1550000	15520	8250	2760
Celtis Occidentalis	Hackberry — Nettle Tree	45.41	72.08	970000	9150	5780	3650
Platanus Occidentalis	Buttonwood - Sycamore	35.38	56.52	1225000	8770	6230	2240
Juglans Cinerea	Butternut	25.46	40.66	1450000	8230	5450	1240
" Nigra	Black Walnut	38.11	60.91	1545000	9750	8000	2640
Carya Alba	Shagbark Hickory	52.17	83.11	1980000	16970	9820	3680
" Sulcata	Western Shagbark Hickory	50.53	80.35	1462000	13600	7770	3910
" Porcina	Pignut Hickory	51.21	81.36	1423000	14320	8100	4140
" Amara	Bitternut	47.06	74.74	645000	13170	7200	3320
Ostrya Virginica	Ironwood	51.62	82.42	1936000	17780	7530	3100
Carpinus Caroliniaria	Blue Beech	45.41	72.26	1631000	14200	6880	2900
Quercus Alba	White Oak	46.35	74.39	1373000	10330	7070	2880
" Macrocarpa	Burr Oak	46.45	74.06	1310000	8990	6800	3150
" Bicolor	Swamp White Oak	47.75	76.18	1273000	9570	6800	2970
" Prinoides	Yellow Chestnut Oak	53.63	86.09	1590000	18380	8020	3600
" Nigra	Black Jack Oak	45.64	72.39	1370000	14900	6880	3940
" Rubra	Red Oak	40.75	65.28	1608000	11940	7100	2380
Castena Vulgaris	Chestnut	28.07	44.95	119500	8053	5240	1420
Fagus Ferruginea	Beech	42.89	68.48	1716000	17460	6540	2630
Betula Lenta	Black Birch — Sweet Birch	47.47	75.97	2200000	17160	8670	3070
" Luta	Yellow Birch	40.84	65.34	2280000	17600	8670	2170
" Papyracea	Paper or Canoe Birch	37.11	59.40	1800000	14950	6750	1700
Populus Tremuloides	Aspen or Poplar	25.13	40.10	1145000	9430	4560	1040
" Monilifera	Cottonwood	24.24	38.53	1405000	10830	4680	1060
" Balsamifera	Balsam Poplar	22.65	36.11	1200000	7630	4440	1000
	Balm of Gilead	25.93	41.42	1033000	8230	3760	860
Thuja Occidentalis	Arbor Vitæ — White Cedar	19.72	31.53	727000	8730	4110	770
Juniperus Virginiana	Red Cedar	30.70	49.11	945000	10360	5860	1940
Pinus Strobus	White Pine	24.02	38.47	1195000	9220	5560	970
" Resinosa	Norway Pine	30.25	48.41	1595000	11320	6370	1100
" Banksiana	Jack Pine	29.67	47.50	1325000	9100	5470	1340
Picea Nigra	Black Spruce	28.57	45.71	1555000	11450	5660	1020
" Alba	White Spruce	25.25	40.38	1440000	11465	4720	960
Tsuga Canadensis	Hemlock	26.42	42.20	1280000	10900	5240	1100
Abies Balsamea	Balsam Fir	23.80	38.02	1150000	7000	5030	1000
Larix Americana	Tamarack	38.86	62.16	1790000	9450	7600	1400

BRICK STREET PAVEMENTS.*

As towns grow into cities, and their street traffic increases, pavements become a necessity.

In parts of Illinois, where timber is scarce, and stone and gravel almost wanting, hard-burnt bricks have been used for paving, and the cheapness of the material has commended its use to the people.

In Bloomington, Ill., fifteen years ago, a courtway was paved with bricks as an experiment, and this courtway, exceptional for a first experiment, is still in a fair condition, after scarcely any repairs.

Bricks fit for paving are so different from common bricks, that we have thought some facts about the former might be interesting.

Clay which will make good paving bricks should be able, without fusing, to withstand a sufficient degree of heat, and for a long enough time to render the bricks hard and impervious to water. Yet, while the value of a clay for paving brick depends largely upon its refractory nature, fluxing agents, in proportions yet undetermined, are necessary to render the bricks homogeneous and tenacious.

Fire clays are generally hydrated silicates of alumina. Potash, soda, lime, magnesia, iron, and other elements are sometimes present in small quantities, and render the clay less refractory the greater the quantity of them present. When 6 to 10 per cent is found, the clay will generally melt. When the clay is siliceous, 3 to 4 per cent makes it fusible. When it is aluminous, 6 to 7 per cent of oxide of iron does not render it non-refractory, because aluminites are mostly of a refractory nature.

Lime alone is completely infusible; but in very small quantities in clay, it makes a brick fusible at high temperatures. It is especially to be avoided in clays for paving-bricks, because the heat of burning reduces the carbonate to caustic lime, which in the pavements will absorb moisture and cause disintegration of the brick.

Magnesia in small quantities is said by Egleston to make clay fusible.

The alkalies, from 1 to 3 per cent, make clay fusible.

The change of color in burning is due to iron, or to a small percentage of bituminous material. Iron, beyond 6 to 10 per cent, if the clay is siliceous, usually renders it fusible.

Silica and alumina constitute the refractory parts, and the impurities the fluxing part.

Silica is infusible alone, except at the highest temperatures of the oxyhydrogen blow-pipe. It possesses no binding property,

*Condensed from a thesis by Mr. Edgar Ryan, University of Michigan.

and a clay having an excess of it is rough, and lacking in plasticity and tenacity, thus rendering the bricks weak.

Alumina is highly refractory and is binding. When combined with iron or other bases alone, it makes infusible aluminites; but with silica present, it fuses more or less readily.

The plasticity of clay is due to the fineness of the particles, to the presence of alumina, and to the water of combination, which may be driven off at a red heat, the clay losing its power of combining with water.

The refractory nature of a clay is then due to the presence of alumina and silica in excess, and to the absence of potash, soda, lime, magnesia, and iron.

The characteristics of all fine clays may be said to be, that they do not effervesce with acids; that they make a paste with water, which paste can be drawn out without breaking, and is very plastic; that when dry they are solid, and break into scales when struck; have a soapy feeling, are easily scratched or polished, can be cut into long ribbons with a knife, and appear somewhat like horn.

The commercial test is the only sure way of ascertaining the value of a clay.

Some clays which we will mention have been used more or less successfully in making a paving material.

"MINGO" FIRE-CLAY, HAYDENVILLE, OHIO.

The clay from which the Hayden patent Paving Block (of which a sample is submitted) is made, has nearly the compactness and density of fine-grained sandstone, and yet is semi-plastic. It can be characterized neither as a hard nor as a plastic clay. Nitroglycerine is used in mining it; yet, while apparently very hard, it is readily reduced to powder in the dry pan under heavy rolls. The clay when ground is excellent for laying fire-bricks, mixing easily, working smoothly, and resisting great heat.

The paving block in burning is subjected for ten days to 2,000° F.

This paving block is square in plan, 5¾ inches on a side, and 4¾ inches deep, hollow below to facilitate burning and save material, and having a flat upper surface broken by indentations intended to provide a firmer foothold for horses. These indentations, however, seem to be of little permanent value, as under heavy traffic they are soon obliterated. The blocks are salt-glazed. The outer top edges are slightly beveled, to admit readily a filling of sand, pitch, or other material in the joints after laying. One thousand blocks will lay 26 sq. yds., at 50 cts. per hundred, or $1.92 per sq. yd. The sidewalks are 1½ inches thick and top 2 inches. The endurance of the block is therefore limited to the wear of the top. A block weighs about 9½ lbs., giving about 360 lbs. to the sq. yd.

An analysis of this clay, by Prof. E. M. Reed, is subjoined, and a comparison is made with the well-known Stourbridge clay of England.

	Mingo Fire Clay, Haydensville, Ohio.		Stourbridge Fire Clay.	
Silica	72.24	per cent.	73.82	per cent.
Alumina	16.87	"	15.88	"
Iron	0.16	"	2.95	"
Lime	0.50	"	trace	
Magnesia	trace		trace	
Alkali	1.09	"	0.90	"
Water	5.44	"	6.45	"
Total	100.00	"	100.00	"

PAVING BRICK CLAY, VIRDEN, ILL.

This clay is found in a bed 25 feet thick, lying just beneath a stratum of slate, and 275 feet below the surface of the ground. It is compact, with a distinct cylindrical cleavage, of a light steel-gray color, and emits, when first mined, a characteristic odor resembling that of slate. Although it is blasted out, it has only the hardness of soft slate, and can be reduced to an extremely fine powder free from grit. It has a specific gravity of 2.5595. A piece kept at a white heat in a hard coal fire for twelve hours, was not disintegrated, and concentrated nitric acid failed to produce effervescence.

It is reduced to powder by being first passed through a Blake crusher, then finished in a dry pan crusher. The process is imperfect, as particles of uncrushed clay weighing as much as fifty milligrams have been taken from a green brick. These particles had not apparently been affected by the water used for tempering, and they remain intact through the process of burning, being easily discerned in a burned brick, and rendering it heterogeneous. When tempered with water, the clay becomes plastic, tenacious, and firm, being readily formed into different shapes. A sample is here submitted.

CLAYS FROM BLOOMINGTON, ILL.

These may properly be called "surface clays," and are of three varieties.

"A" is a yellow, aluminous clay, very fine and plastic, found three feet below the surface, in a bed 12 feet in thickness. It is subjected to no process of grinding or reduction, being simply tempered in a vertical pug-mill directly from the bank. It burns to a grayish-red color.

"B" is a hard-pan clay just beneath the "A" layer, and from one to one and one-half feet thick. Great difficulty is experienced in reducing this clay to an impalpable powder. When dug and exposed for one winter, to "weather," or disintegrate, very good results are claimed for it. But when this clay is reduced at once, uncrushed particles occur which cause unequal shrinkage in the

burned brick, leaving small cavities where, in the pavement, water may accumulate and cause disintegration by freezing. Hard-pan clay generally burns from pink to cream in color.

"C" is a blue clay directly beneath the hard-pan clay, and has a depth of from one to six feet. It is plastic or semi-plastic, fine, firm, and very tenacious, and usually burns to a chalk white. In many respects it is similar to the light blue fire clay used for fire and paving brick at Empire, Ohio.

From the experience of the best manufacturers of paving brick, we are led to conclude that fineness of grain in clay is most essential, and where that property is found in a plastic clay, provided the clay is sufficiently refractory, care only is needed in tempering and burning, to produce good results. When fine-grained clay has a compact and hard structure, no pains should be spared to reduce it, in a dry state, to an impalpable powder.

Where the clay is neither dry nor fine, but of desired composition, it may be calcined and then finely ground. This may appear a trivial matter, yet, if two samples of the same clay are ground, the one finely and the other coarsely, the latter will require much more heat before vitrifying to a homogeneous mass; while the more finely it is ground, the stronger and harder the bricks will become, the better they will stand abrasion, and the less liable will they be to break.

THE MANUFACTURE OF BRICKS.

The great diversity in the clays makes the process of manufacture a difficult problem, for the experience gained in one place may be of little or no use in another.

In several towns, notably Ottawa and Virden, Ill., manufacturers use the plant commonly employed for making tile, modified for bricks. At Virden, Ill., where the capacity is 1,600 per hour, the process is in substance as follows: —

The clay hoisted from the mine, is delivered from tram-carts to a Blake crusher, and then finished in a dry-pan crusher. It is then delivered to a tempering machine, and forced from the latter by a screw through the desired mold, whence it issues in one continuous bar, 8½ inches by 4¼ inches in a section. It runs over a series of rollers, and is cut up by wires spaced two inches apart, in a hinged frame worked by hand. The bricks are removed on tram-cars to a dry-house or shed, and left until sufficiently dry. They are then placed in down-draft cylindrical kilns, having hemispherical tops, and burned from 70 to 90 hours with bituminous coal, on grates, at intervals, around the outside base. An 80 horse-power engine suffices for this plant. The heat is sufficient to melt tin, and to cause pieces of copper to run together.

"A" and "B," of dimensions 8⅛ in. by 4¼ in. by 2 in., are burned in the same kiln, but differ in color and quality. "A" is dark, almost black, rings more and appears stronger than "B,"

which is a light red. They are quoted at $8.00 per thousand free on board cars. "C" is a brick from the same clay, and made in the same way, but intended for a finished brick for face work on buildings.

At Bloomington, Ill., the "A" clay is simply tempered in a vertical pug-mill, molded into bricks by hand, dried in a yard, racked in rectangular stacks, and burned for from 96 to 120 hours with wood and bituminous coal placed in the usual arches. It is a grayish red in color, 7 in. by 3½ in. by 2¼ in., quoted at $8.50 per thousand at the yards, or furnished in sufficient numbers to lay *two* courses, one flat and the other on edge, for $1.12½ per sq. yard. Bloomington "B" and "C," quoted at the same figures, have about the same dimensions. All have a sharp, clear ring when struck.

Bricks are made at Ottawa, Ill., from fire-clay which is mined, and from common surface clay. They are burned some 50 hours with bituminous coal, in kilns similar to those used at Virden. When burned, the interior is dark gray in color, very hard, and cannot be cut with ordinary tools. They are of two dimensions, 4 in. by 5 in. by 12 in., and quoted at $1.00 per sq. yard, which is about $35 per thousand, and 4 in. by 4 in. by 12 in., at 75 cts. per sq. yard, or about $28 per thousand.

At Empire, Ohio, a light blue fire-clay is taken from a drift in the side of a mountain, ground in a pan, molded by hand, and burned in up-draft open-top kilns, with natural gas. The bricks are hard, ring like steel, and are quoted at $10 per thousand. Much the same process is employed at New Brighton, Pa., where the bricks made from fire-clay are claimed to be as hard as granite, to emit a sharp, steely ring when struck, and to resist all effects except natural wear.

In all the above cases, no addition of sand or other material is made. In Wheeling, W. Va., a brick, in form a truncated pyramid, is made from clay and iron slag.

As the condition and life of a pavement depend upon uniformity of the bricks, they should all be burnt to a uniform hardness, which cannot be obtained in ordinary kilns. If soft and salmon bricks are found at the top of the kiln, while those next the arches are over-burned, warped, and melted, the cost of the rest, suitable for use, is much enhanced by the waste.

CRUSHING STRENGTH.

All specimens were crushed by the direct application of weights. The specimens were all ¾ in. by ¾ in. by 1½ in., placed on end between pieces of soft pine about ¼ in. in thickness. The length chosen for the samples permits the shearing action to have its full effect. All were ground to true size on emery wheel and grindstone, and carefully calipered.

In Virden "A," the short axes were parallel to the 8½ in. and 4½ in. dimensions of the brick from which it was taken. It was compact, having no holes or spongy places, took on sharp corners and smooth surfaces, was excessively hard, and would glaze at a white heat on the emery wheel. With 5,266 lbs., it crushed by a scale of about ⅛ in. by ½ in. by 1 in., first flying off from one vertical edge, accompanied by a sharp report, immediately followed by splitting into nearly prismatic fragments, parallel to the action of the force.

A second specimen from the same brick, with short axes parallel to the 4½ in. and 2 in. dimensions of brick, crushed at 5,625 lbs.

Virden "B" did not take on as true dimensions as "A," though free from holes. Crushed at 5,160 lbs.

Virden "C," like the preceding, crushed at 4,985 lbs.

It was difficult to bring Bloomington "A," as well as the next specimen, to the required dimensions, because of a tendency to scale, when heated under the action of the emery wheel. Several holes occurred in them, as may be seen in the bricks. They also glazed somewhat under the emery wheel. Crushed at 5,693 lbs.

The second specimen crushed in smaller prismatic pieces, at 7,268 lbs.

Bloomington "B" was excessively hard to reduce to size, would also glaze, but not scale off, took on smooth surfaces and sharp edges, and had spots which contained a yellow powder. Crushed at 5,565 lbs.

Bloomington "C" was much like the above. Crushed at 5,280 lbs.

In the following table are given the specific gravity (mean of 5 determinations), the absorption for three, five, and ten days, after the specimens had been heated to a red heat, cooled in a desiccator and weighed, and finally the crushing strength per square inch of section.

Name.	Specific Gravity.	Per Cent Absorption.			Crushing Strength, lbs. on sq. inch.
		3 days.	5 days.	10 days.	
Bloomington "A"...	2.1852	3.79	3.92	4.06	12,920 max. 11,520 mean. 10,120 min.
" "B"...	2.3045	3.18	3.19	3.37	9,893
" "C"...	2.2269	1.87	2.20	2.70	9,386
Virden "A".....	2.3166	3.10	3.12	3.82	10,000 max. 9,680 mean. 9,361 min.
" "B".....	2.4150	7.67	7.96	8.71	9,173
" "C".....	2.3601	7.11	7.48	8.70	8,862
Hayden Paving Block..	2.2861	3.25	3.38	3.64	....

It may not be amiss to compare the crushing strength of the above with that of some common or building bricks.

Good Haverstraw stock bricks of a fair average, tested at East River bridge, by Mr. Abbot, with no packing between brick and machine, gave —

		Crushing strength.
Whole brick on end	max.,	3,060 lbs. on sq. in.
	min.,	1,600 " "
	average,	2,065 " "
Half brick on flat side	max.,	4,153 " "
	min.,	2,669 " "
	average,	3,371 " "
Half brick on small side	max.,	6,400 " "
	min.,	2,900 " "
	average,	4,612 " "

Experiments by Prof. W. A. Pike, Minneapolis, Minn., on building bricks. Half bricks between pieces of pasteboard.

		Failed with.
St. Louis, Mo., brick	flatwise,	6,417 lbs. on sq. in.
	edgewise,	4,080 " "
Hastings red brick	hard,	2,017 " "
	medium,	2,012 " "
	soft,	1,748 " "

BRICK PAVEMENTS.

Paving bricks are sometimes laid on a foundation of broken stone covered with cement mortar, and sometimes on sand. It will hardly be expedient to go into details now.

At St. Louis, ten years ago, strips of pavement 22 inches wide were laid down as a test, and a two wheeled cart with tires 2½ inches wide, and loaded to two tons, or 800 lbs. per inch of width, was rolled back and forth by machinery. The heaviest traffic at that time in St. Louis was 75 tons per day per foot of width, and the average for business streets was 35 tons. Estimating the effect of horses' shoes at one-third of this amount, 50 tons per foot were taken as a standard. The samples were weighed before and after testing, and were subjected to an amount of travel by the above cart equivalent to eight and one-half years on the street.

The total abrasion of the fire-brick pavement was 9 per cent., or a depth of ¾ inches, but about one-half of the bricks were broken. Asphaltum blocks under the same test wore 14 per cent., and but one was broken. Granite blocks were scarcely worn appreciably, while limestone had lost 10 per cent. The action of the elements would have affected the limestone still more, as would also probably have been the case with the bricks.

As a result, granite blocks were chosen for streets having heavy traffic. The tests seem to warrant the claim that brick pavements will answer well for moderate and light traffic.

Soft bricks intermixed may give trouble; but the first cold season will usually determine whether the bricks are hard enough,

as, if not, the moisture absorbed by them will freeze, and crumble the bricks by expansion.

At Nashville, Tenn., are used creosoted or bitumenized bricks, prepared by saturating common kiln bricks of medium hardness, under a high degree of heat, with liquid pitch, obtained by distilling coal-tar. These bricks have been laid about four years, on a good foundation of rolled macadam, bedded on edge in 1½ inches of sand, and rammed tight. They have been subjected to a considerable amount of traffic, and show very little if any wear. The cost was $1.80 per sq. yard for brick and laying on finished foundation.

At Youngstown, Ohio, fire-brick on cement concrete base and sand with pitch in joints, cost for all $1.73 per sq. yard. Their best bricks came from Empire, Ohio, and New Brighton, Pa.

At Allegheny City, Pa., fire-clay bricks from the West Virginia Fire Brick Company have been laid in two layers on rammed and rolled gravel and sand, at a cost of $1.95 per sq. yard, exclusive of grading. The pavement, in use three years, is stated to be very smooth, easily cleaned, and of a handsome appearance.

At Bloomington, Ill., some two and one-half miles of brick paved streets have been laid with bricks of home manufacture, "A," "B," and "C." The sample herewith was under traffic there twelve years. The corner and edge of one end, and also the large scale on the upper edge of the same side, were broken off with a pick in removing the specimen from the pavement. It does not appear to have lost appreciably in width, although the majority did not present so favorable an appearance, having generally lost the upper edges and corners. Such pavements, however, are not noticeably rough in driving over them, and afford good foothold for horses. The brick pavements in Bloomington, generally speaking, are in good condition, and are being constantly extended. They have stone blocks, Nicholson and macadam pavements also, and prefer brick, on the score of cost, durability, lack of noise, home production, ease of cleaning, and repairs. The entire pavement, two layers of brick, including *all materials*, grading, and stone curbs, cost $2.00 per sq. yard, with laborers at $1.60 per day, teams $3.25, and sand 80 cents to 90 cents per cubic yard, delivered.

Jacksonville, Ill., has laid over three miles of pavement with Virden brick. Some down for five years is now in good condition. One piece, of one-half mile, two layers, cost, including everything, engineer's services and all, $1.92 per sq. yard. Sand was filled into the joints in place of pitch.

Cincinnati had a pavement on rolled sand. A failure.

Peoria, Ill., paved two blocks in 1886, and five blocks in 1887, with Ottawa paving brick, and Chicago used the same brick three or four years ago on 63d St. car tracks.

The intersection of Washington and Dearborn Sts., Chicago, was paved with Hayden paving blocks in 1886. In March, 1888, it was found to have succumbed to the very heavy traffic, and crushed.

Galesburg, Decatur, Champaign, and Springfield, Ill., have laid more or less brick pavement within five years, the major part of which has given satisfaction.

New Orleans and Wheeling, W. Va., Steubenville, Ohio, Camden, N. J., and other places, have laid experimental sections.

The disadvantages of brick pavements arise from lack of uniformity in the material, and the liability of incorporating in the pavement brick of too soft and porous structure, which crumble the first winter under the action of frost.

When laid on a solid foundation, the advantages are, cheapness, smoothness, cleanliness, freedom from noise, and sanitary excellence as non-absorbent. See table above.

Taking all things into consideration, it is superior to macadam, wood, and, for a maximum traffic of three tons, superior to granite.

CHAS. E. GREENE.

President. — "Gentlemen, we must not let this paper lead us to think that we live in Ohio or Illinois. We live in Michigan. I have no criticism upon the paper as it is, but we would be glad to know: first, whether we have any Michigan clay good for this purpose; secondly, whether those clays, if we have any, have been fully experimented with, and if so, with what results? Can any gentleman give us any information in regard to that?"

Secretary. — "I think Mr. Appleton knows something about Michigan clay."

Mr. Appleton. — "It is another kind of brick we make. But I understand an experiment is now being made with slate dust, to see what the result will be, and to see if the brick produced will be well adapted to paving."

Mr. Foster. — "I know nothing of brick-making, but I wish merely to state that I made some observations in the Upper Peninsula a good many years ago, when I was engineer of the canal that passed through Lake George. We found in that lake for about 3,000 feet a mass of red clay, very refractory. There was an immense amount of it, to all appearances inexhaustible, enough to supply the entire State for ages."

Mr. Appleton. — "I have been investigating brick-making somewhat, and have found that there is a very good quality of brick made for this purpose in several different sections of the State."

Prof. Greene. — "I have also spent considerable time in looking up this matter, and I think the clay Mr. Appleton talks about does not make first-class brick, but even if it did, you can bring brick into the interior of the State of Michigan from Ohio or Illinois, at a much less cost than from within your own borders."

Mr. Appleton. — "I wish we could do away with this abominable wood pavement. North Lansing is paved with tamarack blocks. Most of our streets here were contracted at about 90 cts. per square yard, and the cobble stone with which we paved the gutters, at from 60 to 65 cents per square yard, and in some instances the cedar, has been put down for 80 cents per square yard, that including the whole business, sand and everything complete. Now this intersection of Capital and Michigan Avenues right here in front of the Capitol, as many of you well know, has been down but two or three years, while the paving on Washington Avenue has been down about eight years. That at North Lansing, where the tamarack was used, has been down about six years, and is now nearly worn out."

Prof. Greene. — "Then taking into consideration the life-time of the pavement, is not the brick pavement much cheaper?"

Mr. Appleton. — "Yes, sir, I certainly think it is."

Mr. Foster. — "When I was in the Upper Peninsula, I found several beds of fire clay only twenty-five feet from the surface, some of which I sent up to the iron furnaces, and it was pronounced first-class fire clay."

Mr. Mc Loughlin. — "I would like to inquire of Prof. Greene if he noticed any difference in the shrinkage of the raw brick and the burnt brick?"

Prof. Greene. — "You will see the shrinkage is not very much by examining these specimens. The shrinkage is very small indeed."

Mr. Appleton. — "The machine that makes this brick is of that style where there is just pressure enough to push the column of clay through the machine, and it is cut off by a wire into bricks of the proper dimensions."

Mr. Mc. Loughlin. — "I have made this subject of pavements considerable of a study, especially as we have decided in Detroit that it is necessary to substitute something for cedar blocks. I have given it about seven years of study, and there has been a great number of tests made to see if bricks could be made to stand the heavy traffic of our streets. Brick for pavement has not yet been made that is not porous, and that will not absorb considerable moisture. Mr. John Gladden has also given this question considerable study, and has spent considerable money, and even gone to the trouble of having special machinery made and an extra kiln built to burn these bricks, and paved the street from his own street to Louise St. with the brick he made. His pavement at the corner of Third and Louise Sts. has been down for about five years, and Louise St. has been paved with cedar blocks. The brick has stood fairly well there, but the traffic is light over that street. I find that in investigating this paving question, we have got to drop this idea of cheapness if we want good pavements, and if we expect to have good pavements, we must expect to put good material into

them, and the best of all is a good foundation. I think engineers will discard sand for a foundation. They will have to come down to cement, and then place stone, blocks, or whatever you wish, on top of that. I think for a cheap pavement, there is nothing like a wood pavement. If you would put under this kind of pavement, concrete instead of sand, I believe you would have a good pavement, but it would be quite expensive. At St. Louis they did some paving with locust blocks placed upon a bed of concrete, and it cost $3.65 per yard. In this method of paving, when your blocks wear out, you still have the bed left intact. You have always got a certain part of your work — the foundation — left upon which to re-pave your streets or make repairs thereafter. Therefore I think we should look at the foundation rather than what we put on top of it. But if you want a nice pavement and one that will last, you should put down a pavement of Trinidad asphalt. It is a question in my mind if it is not going to be the pavement of the future. There are objections to granite pavement in the way of noise. I witnessed in the cities of Brooklyn and New York a pavement that had been down for fifteen years. It was made of granite blocks of 3½ inches by 6 to 9 inches long and 7 inches deep; that pavement had been laid on broken stone which had been well rolled with a heavy roller, and then on top of that the paving stone which had also been rolled; but in that fifteen years of traffic over it, it had become very uneven, and at the time I was there they were then ending up the blocks, when it would be good for another fifteen years. It cost in the neighborhood of $4.50 per yard, or between $4.50 and $5.00.

"In Washington, where they have finely paved streets, and where they have had the Nicholson pavement, they have discarded it, and have adopted the standard pavement of asphalt. In Buffalo, Medina stone pavement has been preferred to other systems, and that put down there is now on its seventh year; Rochester has quite a large amount of it; St. Paul and several other cities which I might mention, have adopted this Trinidad asphalt pavement after a great deal of inquiry and investigation. The city of Detroit is now agitating this question, after having tested brick, wood, and various other kinds of pavement. We have a place on Michigan Avenue where we tried the brick pavement, but it was not found to give satisfaction. In the choice of pavements, you have got finally to get down to these two facts: You want solidity and elasticity, and these are the elements embraced in the Trinidad asphalt pavement. In the old world the people are still sticking to the stone pavements of one kind and another. Paris uses asphalt almost altogether, although right here I wish to state, what probably most of you know, that there are several grades of asphalt. The Neuchatel asphalt becomes very slippery with wear, but Trinidad asphalt does not. They are using fine sand, and mix with it as much

of the Trinidad asphalt as it will stand, but there is such a thing as taking too much sand In Columbus, this brick pavement is a failure. They pave with vitrified brick, and in slippery weather horses cannot stand on the pavement. They are now going to use asphalt instead. The brick of the best quality costs $1.92 per yard, and the cost of the foundation is still to be included. With the best brick you have, your pavement will cost $3.00 per yard, and I doubt very much whether that would be economy. The $1.65 brick would bring the cost up to $2.00 per yard. I would much rather have the road bed well filled with bank gravel, and well rolled, and then laid with 7-inch cedar blocks, well filled between with gravel. Then sprinkle the streets thoroughly, and they will last much longer than when not sprinkled, as the dry rot will not set in, and for the amount of money you will have a much better pavement than you would have with brick. If you will keep your streets well watered, the life of the pavement will be longer than when left subject to the weather. Any city that wants a *good* pavement should not put down any pavement excepting the asphalt."

Mr. Ames. — "The pavements of Grand Rapids are altogether cedar pavements. It perhaps might be advisable in some localities to use boards under the pavement for a foundation, but in Grand Rapids our soil is well drained, and it is not necessary. We have taken up and replaced pavement where all that we needed to do was to take up the blocks and put them down again, our soil being such that there is no danger of the blocks settling into it. While a city is growing, and the pavements are constantly being torn up for the purpose of putting down gas and water pipes, and putting in drains and sewers, it would hardly be advisable to put down any very expensive pavement; but it might be well for a city which has its growth to do it, along certain streets. Twelve years is the longest we have used pavement."

Mr. Mc Loughlin. — "I don't care what pavement is taken up, if you will hire competent workmen to do the work and not allow the ditcher to set back the blocks or stone, it can be put back in just as good shape as it was originally. But if you make your repairs properly, it will cost a good deal of money."

Mr. Granville. — "In Saginaw, toward the latter part of each summer the streets that are to be opened the ensuing year, are ordered, and upon such streets' being paved, the Board of Public Works, or its officers, order all connections to be made, though the city authorities have no means of compelling the putting in of anything but the sewer connections. They have the power after the pavement is once put down to compel the payment of $25 by the property owner who wishes to make any connection before entering the pavement, and then if they cut into the pavement over five feet, it is $1.00 for each additional foot. As a consequence, nearly all the connections are made before the paving is done. Now suppos-

ing at some future time a person wants to make connection, he makes his application, and agrees to pay all the damages of taking up and replacing the pavement; the street superintendent, or men under his control, make all the connections; the contractor or plumber makes the trench and puts in the pipes, when his work ceases, and the work of replacing the pavement is left in charge of the superintendent of streets; and the applicant pays into the city treasury the cost of the work."

Mr. Ames. — "In Grand Rapids, the city engineer has nothing to do with the streets. After the streets are opened, it is then in the hands of the Board, and the city engineer has nothing to do with it. The city has no ordinance compelling the people to make connections before the pavement is put down, and the result is that our streets are continually torn up."

Mr. Mc Leod. — "At Manistee we adopted another system this year, differing somewhat from the one formerly adopted. At the time of putting in our sewers, we put in our lateral sewers. But we have nothing to do with regard to the water and gas pipes. I would like to ask the gentleman from Detroit, what kind of timber or lumber you use under the pavement?"

Mr. Mc Loughlin. — "That would depend a good deal upon the lay of the ground, and kind of soil; where you have a fair sub-soil of clay, a good board is sufficient; where you have boggy soil, a 2-inch plank."

Col. Muenscher. — "If you have a good natural foundation, I think the board foundation is entirely unnecessary. I agree with Mr. McLoughlin in regard to pavements, to a great extent. In the large cities it is all right to put down permanent foundations where the property is worth $500 to $600 per foot frontage, but in the smaller cities where it is worth but $50 to $60 per foot frontage, we have got to have something cheaper, as the paving would cost more than the property is worth. I am in hopes to see brick take the place of wood for pavements."

Mr. Mc Loughlin. — "We had occasion to take up some block pavement that had been down for some years, and we failed to find a rotten block in the whole, although it had been down so long that the blocks which were originally seven and a half inches high, had in many places become worn down to two and a half inches. They have in all Canadian cities a system of pavement with blocks, and their streets are sprinkled thoroughly every day, and any wood that is put down in that way is a good pavement, and much cheaper than brick. Chicago has adopted granite for its pavements, but the noise and the rumbling and roar of their wagons passing over them, make it very disagreeable, especially for residence streets."

Mr. Watkins. — "Here they all adopt a block that is seven or eight inches in length. Why not have a block only three or four inches, as it will be less liable to tip?"

Mr. Mc Loughlin. — "We find from experience that a seven-inch block is the best to use."

Mr. Watkins. — "In New York City, where I have seen all those various pavements go to the wall after a little while, the Rust pavement seems to be the best one for the larger cities. For small cities I think a short cedar block pavement is the best thing we can get."

Mr. Goodale. — "We have a small place of about 1,000 inhabitants, yet we need good streets, and we think we can afford good pavements. We have put down stone gutters with gravel and clay between. I would like to know what the comparative utility and cost of the stone pavement is as compared with cedar blocks."

Mr. Appleton. — "Cedar block pavement, with its excavation, costs from 80 to 90 cents per square yard."

Mr. Mc Loughlin. — "How large a block do you use?"

Mr. Appleton. — "We use anything from three to eight inches in diameter."

Mr. Watkins. — "Do you use boards for a foundation?"

Mr. Appleton. — "No, sir, we don't need any here."

Prof. Greene. — "I know of some brick pavements in which the entire cost, including all necessary preparations and engineers' surveys, was only about $2.00 for a good pavement. I understand that the clay found in Southern Michigan is not good for brick for paving purposes."

Mr. Appleton. — "I want to ask the gentleman from Detroit, who just spoke, if he does not find it a rather difficult matter to get good *pavers?* You can find plenty of men who can lay the stone, but you cannot find very many men who can lay it properly. There are all sorts of schemes to get down a good deal of the pavement, but I always found it difficult to get just the right kind of pavers."

Mr. Mc Loughlin. — "There are lots of them; but if you want a good stone pavement, you don't want to go to Detroit to get your good pavers. I can teach any sensible man in two or three hours' time, to lay a pavement, and lay it well. The stone should be laid dry, and rammed down with a rammer that will cover only one stone at a time. Of course it takes considerable time to teach a man so that he can lay to the crown of the street nicely. But no man can pave for me, and lay his 125 or 150 yards per day. If he lays 75 yards, he is doing a big day's work."

Mr. Watkins. — "How should stone pavements be laid?"

Mr. Mc Loughlin. — "The large end up."

Mr. Watkins. — "What is to prevent a person from kicking them right up?"

Mr. Mc Loughlin. — "They should be laid dry, as I said, and then rammed down well. The sand should then be broomed over them, and they should be rammed again, and the sand again

broomed over them, and again pounded down, and so on for three times. I have seen them put down where they could not be taken out with a pick."

NOTES ON BUILDING STONES.

MICHIGAN is surpassed by many other States as a producer of building material. Quarrying is not one of her most important industries. Recognizing these facts, the writer of the brief paper here presented, wishes to offer a few notes on building stones in general, and to call attention to the meagerness of the published information relating to Michigan stone, with the hope and expectation that, for some future meeting of this Society, a more extended and systematic paper may be prepared that shall show in fuller detail what kinds of stone are obtainable within the boundaries of the State, and to what extent it may reasonably be expected that the quarry industry can be developed. The writer wishes to say further that he has had but little opportunity personally to visit the quarries alluded to in what follows, and that he has relied principally for his information about them upon the following publications: (1.) The "Report of the United States Census for 1880;" (2.) The five volumes of "Mineral Resources of the United States," issued by the U. S. Geological Survey from 1882 to 1887; (3.) The reports of the Michigan Commissioner of Mineral Statistics for the years 1878–87; (4.) The several reports of the State Geological Survey. Outside of these publications, there seems to be little or nothing of value in accessible form that relates especially to Michigan quarries.

The United States Census of 1880 made record of such quarries only as did a business in the census year amounting to one thousand dollars or more. Of such quarries there were in the whole country, in 1880, 1,525, employing a capital of $25,414,497, and producing 115,380,133 cubic feet of stone, valued at $18,356,055. Michigan's share in these totals was nine quarries, with an invested capital of $74,700, and a production of 648,060 cubic feet, valued at $79,165.

The nine Michigan quarries of which statistics are given in the census volume, are the limestone quarries at Alpena, at Sibley's Station in Wayne County, and near Raisinville and Dundee in Monroe County, and the sandstone quarries at Lulu, Monroe County, at Stony Point, Jackson County, at Ionia, and at Marquette. No reference is made to the sandstone of L'Anse, though considerable work had been done at that locality as early as the year 1875, nor to the slate of Huron Bay. Besides the places just mentioned, the Michigan reports speak of several other localities where limestone or sandstone, that have either been proved to be,

or are supposed to be, of value for building purposes, have been worked to some extent, or are at least exposed to view in promising outcrops. Among these may be enumerated, though the list is doubtless incomplete, Springport, Sandstone, Parma, and Napoleon, in Jackson County; Flushing, in Genesee County; Trenton, in Monroe County; Bay Port, in Huron County; and numerous points of minor importance in Barry, Eaton, Hillsdale, Iosco, Kent, Saginaw, and Shiawassee counties.

In what has preceded, no allusion has been made to stone other than limestone, sandstone, and slate; and, indeed, there is no reason for expecting to find good building material of the crystalline or granitic character in the State of Michigan, except in the western portions of the Upper Peninsula, or among the boulders distributed through the glacial drift that almost entirely covers and conceals from view the sedimentary rocks of the whole lower Peninsula.

In regard to these rock-names and others in use, it may be well to say a word in passing before speaking more particularly of the quality and value of stone from individual quarries. Rock nomenclature is not in the most satisfactory condition. The popular names, *sandstone*, *limestone*, *slate* and *granite*, are made to cover almost every variety of stone in at all common use, except where occasionally some more specific term finds application; as, for example, *bluestone*, suggested by a characteristic color; or *flagstone*, named from the use to which the stone is to be put; or *Ionia stone*, so called from the locality where quarried. The term *slate* is a convenient one to apply to any rock that readily cleaves into thin plates with surfaces approximately parallel, and *sandstone* is a term generally applicable to rocks made up essentially of rounded grains of quartz, or other hard mineral held together by a cementing material of some kind or other, though it must not be supposed that all slates are alike, or that all sandstones have the same properties; but *limestone* includes not only the common, coarse varieties, but also the finer grained and more highly prized marbles and the so-called dolomites, or magnesian limestones. The name *granite* is perhaps the most abused of all. True granite is a mixture of quartz, feldspar, and mica, in which the different mineral ingredients are crystallized together, and are large enough to be recognized by the unassisted eye; but some rocks, locally known as granite, are nearly or quite barren of quartz, feldspar, or mica, and resemble true granite only in their crystalline granular texture. The traps, porphyries, greenstones, basalts, serpentines, etc., need no further mention at this time, for the reason that they occur in Michigan only in limited amount, or, at any rate, with only a very limited use for structural purposes. In the vicinity of Ishpeming, in the Upper Peninsula, marbles and serpentines do, indeed, occur, that take a good polish, and furnish pretty hand specimens, but, so far as known to the writer, they

are not obtainable in large, homogeneous blocks such as would be required for building purposes.

In determining whether any rock, by whatever name it may be known, is likely to prove serviceable as a building material, especial attention must be directed to its texture, that is, to the way the individual mineral ingredients of which it is composed are held together. In respect to texture, two great classes of rocks are recognized; viz., the crystalline and the fragmental. In the former, the mineral grains are held together by the mutual adhesion of crystalline surfaces, while in the latter, the rounded or the angular fragments, that once existed in other relations as parts of other rocks, are held or stuck together by the intervention of some foreign substance that acts as a mortar or cement. It hardly needs to be mentioned that the strength, durability, and value of a fragmental rock depend fully as much on the character of the cement, which may make up only a small portion of the total volume, as they do on the rock fragments that compose the mass of the rock. Crystalline rocks occur in greatest abundance in regions where eruptions of molten matter have taken place, or where sedimentary formations of great geological antiquity have been metamorphosed through the agency of moisture, pressure, and heat. It is for this reason that in Michigan the crystalline rocks are limited to the districts mentioned above, and that throughout the Lower Peninsula, where the geological formations underlying the drift range from the Upper Silurian to the Carboniferous, rocks of a fragmental, sedimentary character are the only ones to be expected, unless possibly a few of the limestones may exhibit to some extent a crystalline or subcrystalline character.

The well-known quarries of red, or reddish brown, sandstone at and near Marquette, are referred by geologists to the Potsdam period at the base of the Silurian system. The mottled appearance of some of this stone is due to the unequal oxidation of the iron that is present. The rocks of the other geological formations of the eastern portion of the Upper Peninsula appear to be too thinly bedded, too friable, or too much cut up by cracks and seams, for the production of blocks of desirable shape and size. The sandstones of the more southern counties of the Lower Peninsula are mostly subcarboniferous in age; the Ionia quarries are in the coal measures.

To be of value as a building material, a stone must possess sufficient strength, must be capable of resisting climatic and meteorological changes, must present a pleasing appearance, and must be obtainable in large quantity at low cost. These desirable properties are not dependent entirely, nor even to any large extent, on the mineral constituents of which ordinary rocks are essentially composed, for these minerals are all of the most common varieties; but rather on closeness and compactness of texture, on density and degree of consolidation, the character of the cementing material,

if any, and freedom from accessory ingredients, that, though small in quantity, frequently cause discoloration or disintegration and decay of the rock mass, in consequence of slow chemical changes that take place in them when exposed to the action of air and moisture.

So far as ability to resist crushing is concerned, it is safe to assert that in all ordinary structures, there is little or no danger of a rock's breaking or cracking under the load it has to carry, if only ordinary care is exercised in its selection. About fifteen years ago a report of experiments upon various American building stones was prepared by General Q. A. Gillmore, of the United States Army, and from this report it appears that of seventy-eight granites tested, the crushing strength in pounds to the square inch ranged from a minimum of 7,750 to a maximum of 22,750; for forty-seven limestones and marbles the minimum and maximum were 6,650 and 25,000; and for fifty-eight sandstones, 4,025 and 17,725. These figures do not agree exactly with those given by other experimenters, but they may be accepted as an approximation to the truth, and they certainly show that the stones in the lower courses of masonry are still abundantly able to sustain the weight of the superstructure in the highest building or column yet erected. There is still room for extensive study of questions relating to the causes of fractures along certain planes, and the development of weakness in certain directions under varying circumstances.

Among the several conditions that affect the durability of rocks, their porosity is one of the most important. Notwithstanding the apparent solidity and closeness of grain of the stones seen in daily use, it can be easily shown that many of them are porous in no slight degree. The pores and openings are indeed small, but their existence is made manifest in several ways, notably by the absorption of water. To show the extent to which different varieties of rock are capable of absorbing water, the following data are taken from Dr. T. Sterry Hunt's "Chemical and Geological Essays." The numbers represent the volumes of water absorbed in each case by one hundred volumes of rock. For fourteen kinds of sandstone experimented upon, the volumes of water absorbed ranged between 1.39 and 21.27; for five shales, between 0.75 and 7.94; for five limestones, between 0.30 and 1.70; and for twelve dolomites, between 2.15 and 13.55. In the most porous rock the absorption amounted to more than one-fifth its original volume.

Where any high degree of porosity exists, it is evident that this circumstance alone will facilitate the decay of a rock by introducing into its interior the agents of chemical change that are to be found in all atmospheric waters. What these chemical agents are, and how they act in association with mechanical and organic causes of destruction, would be an interesting subject for discussion, but such a discussion does not fall within the scope and purpose of the present paper.

PROF. W. H. PETTEE.

President. — "I feel rather humiliated that I should have to live in a State so long, that has in it no building stone fit for building purposes. I knew, of course, that when we wanted to build large buildings, like the State Capitol, we have to send outside of the State for building stone, but it seems to me we should have abundant material of that kind for smaller buildings."

Mr. Foster. — "We are not entirely destitute of good building stone in this State. At Portage Entry, near the light-house, there is a much larger quarry, and it is better equipped, than many in other States from whence we procure our stone. The stone is sent from there by means of scows to Marquette for building purposes, and they are using it to a considerable extent. The new Mining School at Marquette is being constructed out of it. It has the advantage of being located at a point that is very accessible, with a roadstead for a good harbor. Then on Isle Royal, I believe, on Siskowit Bay, there are cliffs, miles in extent, of stone that is of fine quality for flagging and paving stone, and this is also provided with a good harbor, being situated on the extreme south side of the island. No quarries have been worked there, although people from Chicago have looked at them, but have opened no quarries yet."

Mr. Watkins. — "What about Grindstone City stone?"

Mr. Pettee. — "That stone is used especially for grindstones, and I am not aware that it is quarried for building purposes."

Mr. Rothwell. — "I would also add that in the years from 1876–80 there were over 27,000 cubic yards of stone taken from Limestone City for use at the 'Soo?'"

President. — "Are there any other kinds of stone used in building at the 'Soo?'"

Mr. Ripley. — "Sandstone is used to a considerable extent, in fact, almost entirely for foundations to buildings, and there are one or two churches built with it."

Mr. Rothwell. — "There is some good building stone to be found in the quarries at Big Bay De Noquet and on the eastern side of Green Bay, although they have been worked but little."

Prof. Carpenter. — "There has been considerable of the Ionia and Grand Ledge stone used in this city for building purposes. It has been found to stand well. The Grand Ledge is of very poor color, but is found to be quite durable, and would be quite desirable stone for building purposes were it not for the dirty streaks running through it."

Mr. Ames. — "The stone procured from the sandstone quarries at Holland is of a light gray color, and when first quarried is quite soft, but grows harder upon being exposed to the air for a time. I have never noticed any discoloration from iron."

TIME AZIMUTHS.

It may not have occurred to many of our surveyors that in the recent establishment of Standard Time, we have a new means of finding meridian, — not new in a literal sense, for it is well known to navigators, — but new in that it has not been utilized by land surveyors.

We already avail ourselves of the properties of the "astronomical triangle," so called, for the purpose of finding meridian with the solar campass, or transit.

In this we determine the zenith angle of the triangle, and thence the supplement, mechanically, from the three sides, — a case of spherical Trigonometry.

But in the method I propose to bring to your notice, we have in the same triangle the two sides meeting at the pole, and their contained angle, which we may assume at pleasure, from which to find the zenith angle.

The two sides we have from the same source as when working with the solar transit.

The third elemont, — the angle at the pole, — called also the time or hour angle, is now known from the standard time established, and the *equation of time* as given in the nautical almanac.

From standard, which is mean time, and the equation of time, *apparent time* is readily deduced, which at 15° per hour gives hour angle for any instant between the meridian of the observer and that of the sun, or star, as seen from the pole.

The question is to deduce from these data the bearing of the sun, as seen from the observer.

This will require a knowledge of our latitude and of the sun's declination approximately, and of our *local apparent time precisely.* Though the azimuth is a function of the three elements, it depends most immediately on the time angle.

If we know the latitude to a few minutes, or one-fourth of a degree, it is quite sufficient. The sun's declination is given precisely in the nautical almanac, but if we have it for the second or third year after leap-year, it is sufficiently precise for any of the four years, for ordinary work.

The importance of precision in the apparent time, is seen by consulting the tables of time azimuths, in use by navigators.

By these it will be seen that when the sun is near the meridian, the rate of change of azimuth is much more rapid than when farther away. Thus, in our own latitude of say 42°, with declination 20° N., the sun changes azimuth 10° in the first 15 minutes of time from the meridian, or 40′ of azimuth per 1 minute of time.

At 2 hours from the meridian, the rate is reduced to 20′ of azimuth per 1 minute of time.

Also, the rate of change is reduced by increase of distance from the Prime Vertical. Thus for lat. 42° N. with declination 20° S., and for time angle 4 hours or 60°, the rate of changes is only about 10′ per 1 minute of time, whence, *the best results are found with the sun as far from both meridian and Prime Vertical, as practicable.*

The problem of finding longitude is not difficult, now that the whole country is surveyed, and land-marks established. Every light-house around the entire chain of lakes and rivers, and coast of the country, is an *illuminated land-mark*, whose co-ordinates of place are given, and recorded, to the nearest second of arc, and are furnished for the asking to all owners and masters of American ships.

In the interior of the country, every observatory is a point whose co-ordinates of place are known; and the topographical surveys of the country have determined the location of many other places.

The Government surveys afford the means of counting distances, so that from them the difference of latitude and the difference of longitude can be computed, by knowing the lineal value of these elements for the locality. Then the application of the equation of time gives us *local apparent time.*

I give herewith a table showing the length of one minute of longitude, in statute miles, at every one-half degree of latitude, from 30° to 60°, from which distance east or west, or departure, as we may call it, may be readily reduced to minutes of longitude, nearly anywhere in the United States.

I also give a list of places with their co-ordinates, as taken partly from the "Government List of Lights," partly from "Prof. Winchell's History of Michigan," and partly from "Henck's Pocket-Book." From these, and the Standard Time, which may be readily known to the fraction of a minute, it will not be difficult to find the local apparent time to a good degree of precision.

This being known, the following equation will give us the azimuth corresponding to any assumed time angle, for any latitude and declination.

$$\text{Tan } Z = \frac{\sin H. \cos D}{\cos H. \cos D. \sin L \mp \sin D. \cos L}$$

In which Z = azimuth desired, H = time angle, D = declination, and L = latitude.

The above equation solves the case of spherical trigonometry, —*given two sides and their included angle to find the other parts*— but by a process very different from that given in our text books.

A reference to the accompanying diagram, with a little discussion, will show how the equation was derived, and show the office of each part.

I have written on the several lines their names, so that little further explanation will be needed.

It will be observed that the upper half of the figure represents the plane of the *meridian*, while the lower half represents the plane of the *horizon*, the two planes being at right angles to each other along the lines "North" and "South."

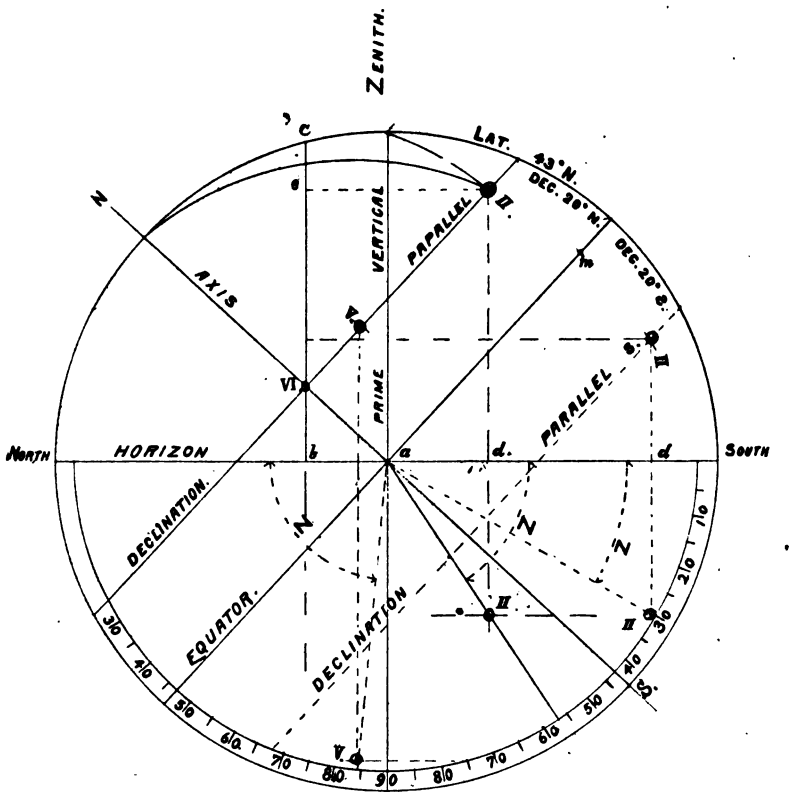

DIAGRAM.

CONSTRUCTION OF THE EQUATION.

The problem is to locate the projection of the sun, or other object, on the plane of the horizon, for any instant of time, whence its bearing is found.

The example projected is for L = 43° N., D = 20° N., and H = 2h. or 30°. Required Z.

It will be observed that the sun, bating the effect of change of declination, travels in a small circle, whose radius is the cosine of D. Also that the projection of the sun on the plane of the me-

ridian for any H or time angle, is the cosine of H on that radius, whence *cos H. cos D.* represents the distance of the sun from the earth's axis, measured along the cos D. (See Diagram.) So that at H = 30°, the sun is seen on the plane of the meridian, at II.

Multiplying cos H. cos D. by sin L, we have *cos H. cos D. cos L* = distance E II., which is the distance of the sun from a plane perpendicular to the plane of the horizon, parallel to the plane of the Prime Vertical, and passing through the center of motion at VI. Thus we have the first part of the denominator.

But we wish to refer the place of the sun to the plane of the Prime Vertical. By looking at the figure, we see that this distance for north declination is too great by the distance *ab* = sin D. cos L., though for South D the distance *ab* must be added. Whence the distance of the sun from the plane of the Prime Vertical, as sun projected on the plane of the horizon, at *a* = cos H. cos D. sin L = sin D. cos L.

The distance of the sun from the plane of the meridian, is the sine of H in terms of the radius of the declination parallel, or as sun from *d* = d II. = sin H. cos D.

Thus, from a well-known property of the plane right triangle, we have, for angle *ad* II. = Z,

$$\text{Tan Z} = \frac{\text{sin H. cos D}}{\text{cos H. cos D. sin L} \mp \text{sin D. cos L}}$$

which is the desired equation.

With L and D of the same name, the declination parallel in which the sun moves will always cross the Prime Vertical *in less than six hours* from meridian. Thus, in our example, it crosses that plane before 5 P. M. or 8 A. M., and the projection of V is seen at V′ on the north of the Prime Vertical, and the angle Z is measured from the north, as shown.

I have shown the place of the sun for S declination, and H = 2 h. at II′ and II‴.

I think the student will have no trouble in apprehending the full idea of this problem from the preceding explanation, which may be open to the objection of being more diffuse and elementary than good taste would warrant. But as this is a new solution of the problem, I wished to be sure of being understood.

The one objection to this method, is the necessity of great precision in the finding of the *local apparent time*, and the consequent error of the watch. But the advantages are many.

We require no expensive instruments, as "*Solar Attachment*" for transit, and no sextant. We have to make no observations for latitude, as we can find that element near enough, from maps; no corrections for refraction, or semi-diameter.

The surveyor should make his computations beforehand, and note the time by his watch, when the sun is at any given distance from the meridian, with the corresponding azimuth.

He should set his Z angle off to the *left* of the zero of his instrument plate in the forenoon, and to the *right* in the afternoon; then, a few minutes before the time for an observation, direct his telescope to the sun, and keep it there by means of the motion on the spindle, the plates having been clamped. At the time the watch indicates the given time for which the azimuth was computed, clamp the spindle motion, and turn the plate vernier back to read "O," *when the telescope will be in the meridian.*

A little practice will make the observer expert in this matter.

Following is the numerical work of the above example, which we have treated graphically: —

L = 43° N.	Cos. (H = 30°)	Log. 9.93753	To find Z	
D = 20° N.	Cos. (D = 20)	" 9.97298	Sin. (H = 30°) =	9.69897
H = 2h = 30°	Sin. (L = 43)	" 9.83378	Cos. (D = 20) =	9.97298
Corresponding number	= .5550	= — 1.74429		— 1.67195
			.3049 "	— 1.48416
	Sin. (D = 20°)	" 9.53405	Tan. Z.	= 10.18779
	Cos. (L = 43)	" 9.86423		
Corresponding number	= .2501	= — 1.39828	Whence	
Divisor	= .3049		Z = 57° 1′	

LATITUDE AND LONGITUDE OF A FEW PLACES IN MICHIGAN AND VICINITY.

Place.	Point of observation.	Latitude N.	Longitude W.
Lake Survey.			
Little Traverse	Light.	45° 25′ 07″	84° 58′ 05″
Charlevoix	"	45 19 15	85 15 21
Manistee	Pier Head Light.	44 15 00	86 20 37
Muskegon	"	43 13 39	86 20 08
Grand Haven	"	43 03 30	86 20 30
St. Joseph	"	42 06 47	86 29 19
Michigan City	"	41 23 21	86 54 22
Chicago	"	41 43 21	87 36 35
Milwaukee	"	43 01 36	87 53 51
Escanaba	"	45 44 40	87 02 30
Marquette	"	46 32 48	87 22 35
Duluth	"	46 46 49	92 05 11
Prof. Winchell.			
Detroit	St. Paul's Church.	42 19 46	83 02 23
Saginaw	Light-house.	43 38 38	83 50 54
Ann Arbor	Observatory.	42 16 48¼	83 43 43
Niles	Trinity Church.	41 49 46	86 15 37
Traverse City	Pier Head.	44 46 00	85 36 53

VALUE IN STATUTE MILES OF ONE MINUTE OF LONGITUDE FOR EACH HALF DEGREE OF LATITUDE, FROM 30° TO 60°.

Latitude.	Miles.	Latitude.	Miles.	Latitude.	Miles.
30°	.9991	40°	.8842	50°	.7422
½	.9940	½	.8778	½	.7345
31	.9889	41	.8712	51	.7268
½	.9837	½	.8646	½	.7190
32	.9784	42	.8579	52	.7111
½	.9731	½	.8512	½	.7032
33	.9676	43	.8443	53	.6952
½	.9622	½	.8375	½	.6872
34	.9566	44	.8305	54	.6790
½	.9509	½	.8235	½	.6708
35	.9452	45	.8164	55	.6626
½	.9394	½	.8093	½	.6544
36	.9336	46	.8021	56	.6460
½	.9277	½	.7949	½	.6377
37	.9217	47	.7875	57	.6293
½	.9157	½	.7802	½	.6208
38	.9095	48	.7727	58	.6123
½	.9033	½	.7652	½	.6048
39	.8970	49	.7576	59	.5551
½	.8907	½	.7500	½	.5865
				60	.5778

H. C. Pearson.

President. — "The paper of Mr. Pearson will appear much better to us all when we have it in proper form. When we get it into our report with the tables that are here given, the paper will appear much more useful than it does here."

PINE LAND SURVEYING.

Mr. President and Gentlemen: —

Last summer while at work on the head-waters of the Thunder Bay and the Cheboygan River, a letter from our Secretary was forwarded to me from my home in Saginaw, requesting me to write a sketch of my daily life in the pine woods. The manuscript (with the exception of the date of the completion of the survey) was written during my leisure moments while sitting, "tailor fashion," on my bed in my tent, with a box of stationery by my side.

Before the United States Government disposed of the land in Michigan, surveyors were sent who divided it into sections one mile square, containing 640 acres each. They marked trees on

the lines each way, thus surrounding each section with a line of "blazed" trees, then sold it in tracts of one or more "forties" (that is, forty-acre lots, being one-fourth of a mile square), as the purchaser desired. If he buys less than a whole section, or sixteen forties, he must get the interior lines marked at his own expense.

When a lumber firm wishes to cut the timber on their land, they usually send men to cut out the "tote road," or road on which to draw supplies from the nearest road already built, and build the camps, then send for a surveyor to mark the lines around the land to cut by.

Years ago some firms made a practice of having the camp foreman or some "land-looker" (a man who makes a profession of examining wild land to estimate its value) run the lines with a small hand compass, and sometimes measure the distance with a pole or tape; but more commonly by "pacing," stepping off the number of steps that experience teaches him will make the required distance. Different men take different numbers to make the same distance, as some take longer steps than others; but in the last few years, "stumpage" (the value of standing timber) is so much more valuable that owners of adjoining land are watching so closely that it does not pay to take the risk of having to pay for timber cut on the land of other parties.

When the foreman sends to the office of the company, that he is ready for the surveyor, that he "must have him at once, cannot wait," as is usually the case in Saginaw, if the same call comes from a dozen or more camps at about the same time, the surveyor is at his wits' end to know how to do all the work. He surely cannot do it all at once, and he does not want to refuse any; so he makes all sorts of promises, to put off those he cannot accommodate first, usually promising to go from one camp to another nearest to where he does his first work. He takes his compass and chain, and goes to the nearest point reached by public conveyance, and if he is so fortunate as to meet the "tote team" from the camp, he will ride to camp on a load of supplies, or, as is frequently the case, if the road is so rough that it is harder work to ride than to walk, he puts his tools on the load and walks behind, usually getting into camp at night. He makes himself known (if he is a stranger) to the foreman, and asks for help for the next day.

The camps are now usually built so as to have one building exclusively for cooking and eating, with a bed in one corner for the cook and "chore-boy," (it makes no difference what his age is, he is "chore-boy" all the same), and one building for the men to sleep in, with "bunks" on each side and sometimes across one end. They are wide enough for two, and are usually one above another. Stationary seats are made in front of them, level with the lower bunks. At the end of each bunk, is a post of round timber which reaches above the upper bunk, with a one-and-a-half or two-inch hole bored through at the bottom of each bunk, into

which is fitted one end of a round stick, the other being in a like hole bored in the log of the side of the camp. On these the boards are laid which form the bottom of the bunks, with a narrow board set on edge in front and another cut and fitted from this to the log, to form the division between the bunks. The bed consists of a tick filled sometimes with straw, but more often with hay, over which a blanket is spread, and usually two pairs of blankets for a covering, each man furnishing his own pillow, usually the clothing he wears through the day. Sometimes his "turkey," a common grain bag containing his extra clothing, serves for a pillow. Sometimes the bed tick is omitted, and the hay put into the bunk loose.

Towards the door (which is in one end) from the center of the camp, is a large box stove, on which usually stands a galvanized iron kettle filled with half a barrel of water kept hot for washing, and mixing horse feed. The pipe runs up high enough to be out of the way, then turns and runs back of the center, where it again turns and runs out one side of the center of the roof, as there is a large log in the center on which one end of the roof-boards rest, the other end resting on the top log of the side of the camp, and supported in the middle by another large log, running lengthwise of the camp. From one to the other of these, under the stove-pipe, are a number of wires taken from baled hay, on which wet clothing is hung in the evening to dry. The roof-boards are covered with tarred paper instead of shingles, thus making it nearly air tight, and retaining the steam from wet and soiled clothing, the breath of the whole crew, etc. A person entering the room in the night would, with the first breath he inhales, be tempted to retreat.

Next the door, one bunk is left out, as a place to pile wood on one side and for a wash-room on the other. A long sink is made, extending from the door to the corner, with the corner end the lowest, and a spout through the logs to a ditch on the outside. A pork-barrel is set in the corner and filled with water, into which the wash-dishes are dipped for washing; and by the time forty or fifty men wash, and wipe on the two or three towels which are furnished, they are not very dry or clean; consequently it is advisable to carry a small towel in your pocket for your own use.

In most camps there is a small building for an office, in which is kept a stock of clothing, tobacco, and other things that may be needed, to sell to the men during the winter. These are kept on shelves at one side, near the door, in front of which is a counter. In the back end are beds for the foreman, clerk (if they have one), scaler, and visitors. Here the surveyor usually sleeps; if not, he must sleep with the men in the other camp, and take the consequences, which are not always pleasant, as the blankets sometimes contain undesirable bed-fellows.

About five o'clock in the morning, the chore-boy blows a tin horn, which is from four to six feet long, and can be heard for

miles. This is an invitation to get ready for breakfast, and gives the men time to dress and wash, when a single blast of the horn announces breakfast ready, on the table, and getting cold; and he who wants it warm must get there to eat it.

No talking is allowed in the "cook-camp" at meal time. Each man has his particular seat, rushes to it, helps himself to whatever he wants, if he can reach it, if not, asks his neighbor in a suppressed tone to help him, eats as though a fortune depended on his finishing the meal in so many minutes, and is on his way to the door before he swallows his last mouthful.

This is a description of camps as they are now built, where saw-mills are convenient to secure lumber, and transportation facilities are ample to carry in stoves, etc.; but years ago the camp was covered with "shakes," thin pieces of pine split from a log about three feet long, and laid from one pole to another, which usually (but not always) kept out the rain. But "shakes" offered no resistance to the wind, or the drifting snow. There was also a "caboose" in the center, made of logs ten or twelve feet long, forming a square, notched into each other at the ends so as to be level with each other. This was filled with sand, on which the fire was built, frequently made of half a cord of hard green wood. There was a hole in the roof for the smoke to escape. When the fire burnt down, it left a large mass of bright coals, over which the food was cooked, the cooking and sleeping being done in the same room. The bread and beans were baked in the "bean-hole," a hole dug in the corner of the caboose, with some live coals and hot ashes and sand put in the bottom. The bread or beans were put into an iron pot with a tight cover, which was set in, then covered with hot coals and ashes, and left until properly cooked; in the case of beans, all night. At that time the men were less liable to sickness than now, as they were sure of plenty of fresh air, the only adulteration being smoke and ashes, which were frequently more plenty than pleasant.

The foreman will detail as many men as the surveyor wants, usually one axman and two chainmen, from those he can best spare. If he has any that are good for nothing else, he will send them, as all the best men have work that must go on. He usually goes with the surveyor to some corner on the Government survey, then leaves him to find the rest himself. Where the brush is not too thick, the surveyor goes ahead, keeping one eye on his line, and the other on the chainmen, followed by the axman, who is ready to cut the way through any obstruction too thick to pass without, the chainmen bringing up the rear. The first time through on a line as few marks as possible are made, setting temporary "tally-stakes" at the end of each five or ten chains, according to whether he uses a half chain or a chain (thirty-three or sixty-six feet); and when he gets through to the next Government corner (he should seldom, if ever, assume a corner set by some

other surveyor to be correct), one-half mile or one mile as the case may be, note in his field book the entire distance between the two corners according to his chain as well as the links, to right or left, and the bearing of the random line according to his compass; then correct his bearing and run back, setting the tally-stakes over, *pro rata*, and marking the trees between, thus leaving nothing behind on the random line which might mislead the choppers, while cutting the timber. If a corner is to be set between the two corners measured from, set a temporary post at the proper distance on the random line, and then set it ahead or back, as well as to right or left, *pro rata*, as the section over-runs or falls short. Thus it makes no difference whether his chain is standard length or not. It is practically impossible to keep a chain the standard length, that now used by the writer, one of Gurley's best tempered steel brazed chains, now being 66.58 feet, instead of 66 feet, as it was when first made. Where specified distances are required (which is seldom, if ever, in pine land surveying), the chain, if used, should be tested at the time with a good steel tape, and the proper correction made in the entire measurement.

If, in making his survey, he should find where some owner of adjoining land had cut across the line, whether in consequence of a line not properly run, or from any other cause, most lumbermen require the surveyor to measure the trees so cut, and report to them, which is done by measuring the diameter of the stump, or in case the butt of the tree is defective and left on the ground, the diameter of the top of the piece so left, the diameter of the top of the tree where cut off, which is the diameter of the top of the timber taken, and the distance between, which is equal to the length of the tree. This length he divides into logs of the usual length (as many 16 feet long as possible, the balance 12, 14, 18, or 20 feet), the diameter of the top subtracted from that of the butt. This number divided by the number of logs in the tree, and the quotient (as near as possible, avoiding fractions) added to the diameter of the tree, gives the diameter of the top end of each successive log. Then from his "log-book" or scale-rule, he puts down the number of feet, board measure, in each log, the sum of which gives the number of feet in each tree. He should mark a number on each stump in some substantial manner, cut with a "timber scribe" is the best, and mark the same number on his book for future reference, should his measurement be disputed. It has been the practice of the writer to make his report in a tabular form, giving in the first column the number marked on the stump; next, the diameter of the butt; then of the top, in inches; then the length of the tree in feet; and last, the feet, board measure, in the tree, or "scale," prefaced by a statement of the date of measurement, the date, as near as possible, of the trespass, what particular forty-acre lot, on which side, and stating that it was cut by parties lumbering on a specified piece of land, making the report in duplicate, and his employ-

ers usually keeping one copy in the office and sending the other to the parties who cut the timber (if known). They can, if so disposed, have the lines re-surveyed, and if found to be erroneous, throw out any particular tree without affecting the balance of the report, as well as test the measurement of each tree separately.

When going to camp, if the surveyor does not meet the "tote team" from that camp, or some other near, he must walk to camp, carrying his tools; and when done at one camp, he usually has to walk to the next, frequently through the woods, and without any guide but his hand compass, which the writer is never without, at home or abroad.

This class of work commences in the fall as soon as the camps are built, which is usually in September or October, so as to get the roads made and most of the timber cut and skidded before deep snow comes. Then when good sleighing commences, there is little to do but to haul the timber to the bank of the streams, ready to float to the mills in the spring. About all the calls a surveyor has after that, is in case the owners have reason to think some one has trespassed on their land. Of course, when the snow is deep, it makes hard and slow work, and as little of it is done as possible. This time varies with different seasons, from the middle of December to the first of February.

In the spring of 1887, a firm of Saginaw lumbermen ordered the writer to make a survey of a large tract of land which they owned. There were nearly 40,000 acres of it, located in townships 26 to 36 north, ranges 4 west to 5 east. In the whole tract there were only three whole sections. It was scattered through 272 different sections, in 43 townships and 7 counties. I had already surveyed enough to furnish two seasons' cutting, besides some that was cut over some years ago. As there were settlers all through the townships, and roads already made, I made no preparations for packing, but depended on going with a team wherever we went with the camp.

I bought one "two-men tent" for the cook and teamster, and one tent nine feet square with two feet wall, in which I slept with my two chainmen and two axmen. We put a pole across about 2½ feet from the front, held by stakes, for a "foot-board," leaving a space in front for "turkeys," boxes, boots, etc. For the bed, we picked a large quantity of hemlock twigs, keeping the stems together, then commencing at the head of the bed, laid a layer of them, then another a little back, with the stems on the ground, and the tops on the first layer, and so on till the ground was covered, when nothing was to be seen but the leaves on the end of the twigs. Over this, two strips of oil-cloth were spread, covering the twigs. Then the three beds were furnished with four pairs of blankets each. During the coldest of the weather we used three pairs of blankets over us and one under us, but most of the season, two pairs over us were sufficient. There were but very few nights

during the season that two pairs were too much, as the nights were nearly always cool.

To the front of the tent we pinned a piece of mosquito netting, doubled, with the bottom resting on a log which was staked against the front of the tent. This excluded the mosquitoes, but not the gnats. But by building a small fire in front, they were attracted to it and burnt, thus leaving us to enjoy a good night's sleep undisturbed. We had another "two-men tent," in which to store our supplies. We took a board sixteen feet long and sixteen inches wide, and cut it in the middle for a table, which made it eight feet long by thirty-two inches wide. We drove four crotches into the ground with sticks between each pair, under each end of the table. For seats, we drove four shorter crotches with sticks across under the table and a board on each side. At each end of the table was a crotch about nine feet high, with a pole from one to the other. Over this was thrown an awning nine feet by twelve, with ropes at each corner, which were tied to stakes about five feet high, thus protecting the table from rain or sun. An oil-cloth was spread over the table on which the dishes (of tin) and prepared food were left, and covered with another oil-cloth when not in use. The cooking was, of course, done wholly outdoors, the bread and beans baked in a "bean hole" dug near the fire, in the old "caboose" style. We had our mail sent to Gaylord, Otsego County, and when nearer some other office, had it forwarded to us.

I took the Saginaw Daily *Courier;* which kept us posted on the doings of the outside world; but sometimes we would be where we could not get the papers for a week or two, and at one time, three weeks, then we got them all at once.

We left Saginaw April 25, and returned Sept. 12. On Sept. 19, I went back to the lumber camps with one axman and two chainmen, and remained till Dec. 21, when the snow was too deep to work to advantage. April 30, 1888, I started out again with my camp equipment, and remained till Sept. 19, when I completed the survey of the land. I purchased most of my supplies in Saginaw, and had them shipped to Gaylord, where my team went for them. Some things (especially potatoes) I bought of the settlers. Potatoes are the principal crop raised by them, as they can raise potatoes with much less labor, and of a much better quality, than farther south. They expect (and usually get) a frost every month in the year, thus killing many weeds that trouble the farmer farther south.

J. H. LEAVENWORTH.

President. — "The object of the writer of this paper is not to instruct us how we should run a line, but it is to get into our report the ways of doing this work, and all those little attendant incidents which have occurred and are occurring, but which are fast passing away. The running of these lines will soon be a thing

of the past. It is and should be our object to gather together all these little incidents of what we might properly call pioneer work in this class of work, and all those little incidents of camp life which will soon be forgotten by many, and store them carefully up for future use as a history of how work was once done in our northern Michigan woods."

Mr. Rogers. — "I would like to ask how to get the length of a tree after it has been chopped, and the logs cut and removed?"

Mr. Leavenworth. — "I always instruct the man who holds my tape line to hold it just about where the butt has been cut off, and then measure to where the top is cut off; and then in estimating the number of logs, I never make calculations in odd feet, as I know that logs in the country are always cut in lengths of even feet, and never cut into odd lengths, so if there is a variation of a little, we can always get it pretty accurately."

President. — "I was employed at one time in finding out how much timber had been removed from a certain piece of land that was then in controversy with reference to a trespass suit. These lands were mostly covered at one time with pine timber, but there was scattered through it hemlock, beech, and other varieties of timber, so that we had a considerable timber to work among. It was our object to get every tree, so we had to be very careful in our work. I managed with two men besides myself, and with the aid of a pocket compass and blazes, to get every tree. It was quite a difficult task, at each time as we crossed the land east and west, in some places over a mile long, and others only a quarter of a mile long, to indicate our path by means of the blazes; and it was a great surprise to me that I could find the butt and top of every tree that had been cut, although it had been three years since the timber was removed. By observing very closely, any one can see by the splinters on the stump which way the tree must have fallen, and where it struck the ground; or what is the best guide of anything, the sawdust piles where each log had been cut off at intervals of the length of the logs; and by measuring the diameter of the butt and the top, and the number of logs taken off, you could calculate very closely the number of feet there must have been in the tree."

Mr. Leavenworth. — "I have generally made a practice, especially where there is much underbrush, of following log roads, and keeping either to the right or left; and I found I was always pretty successful in getting the trees by that means."

Secretary. — "I want to speak a few words on the subject of land surveying. I see many new faces here with us, and I have understood there has been a feeling of disappointment expressed by some on account of not having more papers on the subject of land surveying and kindred subjects. Of course, they do not understand the amount of this work that has been done by the

Society. When we first started out, our work was mostly on land surveying. Afterwards, on account of the large number of engineers joining our ranks, we devoted a considerable time to subjects of interest to civil and mechanical engineers, and so we have had to diversify our subjects as much as possible. About 40 per cent of our work up to this time has been in the direction of land surveying, while not that percentage of our members are simply land surveyors. We have traversed the ground so thoroughly in that line that it is very difficult to bring up any question on the subject of land surveying that would be new. When I was preparing a programme for this session, I sent out circulars to the members for topics on the various subjects, and out of that whole lot there was but one gentleman who suggested a topic on land surveying.

"Now there is but one thing that is of particular interest to me in that direction, and that is the decisions of the courts on points connected with our practice in land surveying.

"These decisions can readily be secured by the Society through the American Digest referred to in my report. While on this subject, it may perhaps be as well to call to your attention a recent decision of our Supreme Court. You will remember that at our last meetings I took occasion to criticise some of their decisions, particularly in the cases of Wilson *vs.* Hoffman, Keyser *vs.* Sutherland, Palmer *vs.* Dodd, and Commissioner of Thompson Township *vs.* Beebe.

"In the first case, it was decided that a fractional lot, as sold by the United States Government, could not extend beyond a quarter line. This was re-affirmed in the two following cases. Since my criticism of the doctrine was published, the Supreme Court has ordered a rehearing of the case of Wilson *vs.* Hoffman, and they have changed their former ruling on this point. Here is what they say about it, taken from the thirty-eighth 'Northwestern Reporter,' p. 558: —

"'In this case, when formerly here, the map of the original survey was not so certified as entitled it to be received in evidence, and there was nothing in the case as then presented that showed that the premises described in the declaration, came within the description of the S. E. quarter of Section 28. In the record before us this has been obviated, and the copy of the original plat of the township has been introduced, which shows, according to the Government survey, that the premises in question are embraced in what the Government denominated the S. E. fractional quarter of Section 28, in its patent to Tingley. It might perhaps have been more accurate to describe it as that portion of Section 28 lying south of Black River, but as the fraction contained less than 160 acres, and the law required it to be sold entire, the description contained in the patent was sufficient, and is quite

a customary method of description in the general land office. The conclusion of law which the court below arrived at, so far as it holds that the facts of this case as now disclosed are not contained in the claim embraced in the declaration, is erroneous.'

"It is gratifying to find that, like the Supreme Court of the United States, our own Court deems it better to break away from a precedent, or as in this case, from a line of precedents, than to adhere to an erroneous decision. Since coming here, I have taken pains to look up the original field notes of the section involved in the case of the Commissioner of Thompson Township *vs.* Beebe, and have also examined the full report of the decision in the case. The report does not disclose the fact whether or not there were two sets of section corners on the Range line, but from the surveyor's claim that his line was right, and that the quarter line as he ran it came out some ten or twelve rods from the quarter post for Section 36, one would naturally infer that there were double corners on the township boundary. Such, however, is not the case. The subdivisions were surveyed under the modern instructions, by which the closing lines of the survey are required to close on the standard corners. The line between Sections 30 and 31 was run west as a random line, to its intersection with the range line, and then corrected back for true line. Under these circumstances, I am disposed to accept the decision of the Court as correct, and to recall my former criticism, which was based only on the facts disclosed by the report of the case. I think the Court was right, and that as there is only one set of section corners in the boundary lines of townships, surveyed under the modern instructions, there should be only one set of quarter-posts."

Mr. Watkins. — "I differ with the Supreme Court and brother Hodgman in the matter. I say the Supreme Court is still in error, and I think I can show it to you. Supposing the section corners correspond, but the quarter post is not exactly in the center between them. I have sometimes found it half a chain out of the proper place. Now, if the Government survey is wrong, are we to perpetuate the error in another township because there is an error in the first? — I say most emphatically, No! But I think the subdivisions of each section should be made to depend upon the corners in that section. And where we find the measurement of either one of the lines over 80 chains, give each quarter half of it."

Secretary. — "The surveys in question were made under the instructions of 1855, and in these same instructions it is stated that there are to be double corners nowhere, except on the base and standard lines. Now we had no double corners there, and I cannot see how we can make any."

Mr. Watkins. — "The surveyors should do justice by the parties employing them, and where they have not made corners, we should make them."

Mr. June. — "If the east quarter post is here, and the new quarter post should be set east of it, and on land that is not in controversy at all, which shall be our guide?"

Secretary. — "It has been settled that the township boundary line, where it was run by the United States surveyor, shall be conclusive."

VILLAGE PLATS.

NEARLY every engineer is from time to time called on to make a survey, and plat the part or whole of a village. Those who have had experience, will not profit to any extent by my remarks, as they will be familiar with the subject from every stand-point. I have little reason to think that the members of the Engineering Society here had extra work to do because of the law, excepting myself. I have no doubt that your extensive practice was sufficient to enable you to take in at a glance all the fine points of the law, and consequently no plots were ever returned to you for correction or addition. With myself it was not so. My first attempt, although correct in my own mind, was not in harmony with the legal requirements as interpreted by our Auditor General. I afterward came to the conclusion that he and not myself was correct. These few words are written, then, entirely for the benefit of young engineers, and explain the process in detail, as concisely as possible. A circular containing the law and certificates can be had by addressing the Auditor General at Lansing. The process is as follows: —

Procure three sheets of muslin-backed paper, each 18 x 24 inches in size. The first of these will be termed the original drawing, and must be submitted for approval, as soon as completed, to the Auditor General. This must contain the certificate of dedication from the proprietor, a description of the land platted, and the surveyor's certificate. This, after being approved by the Auditor General, will become the property of the proprietor.

An exact copy of this plat, with the addition of a certificate of comparison to be signed by the Register of Deeds and the surveyor, for filing in the office of Register of Deeds of the county, must then be made. This second copy must contain a copy of the Auditor General's indorsement of approval. Still another exact copy must be made, containing all the certificates of the second copy, and in addition, one signed jointly by the surveyor and Register of Deeds, as to its exact agreement with the second copy. This is sent by the Register to be filed in the office of the Auditor General. The above is the general outline of the law, and should be fully comprehended before the details of construction are attempted. Indeed, I think most of the trouble experienced has come from not realizing the use and necessity of the three copies.

The details required are clearly set forth in the circular issued by the Auditor General, and I doubt that much trouble has been caused on that account. The principal on which these requirements are founded is the reasonable one that either map or description shall be complete in itself, and further, that a sufficient number of dimensions shall be put on the map to preclude any necessity of using a scale. This gives two or three checks on the correctness of the work, and would be valuable in detecting any error in any one of the methods. To carry this out, first our plat should show a complete and full description of the area to be platted; secondly, our map should be accompanied with a scale and meridian, and should show the location of all fixed monuments; thirdly, distances should be written on the map for each boundary line, for the width of lots and streets, and for the dimension of the scale. Our present law requires permanent monuments at all street intersections, and at each change of direction in the boundary line. The monuments at street intersections are not required at the center of the streets, or in any other specified position. The surveyor should use his judgment in locating his monuments, so that they will not be likely to be removed in making village improvements. The borders of the streets, or the curb lines, are not so likely to be disturbed as the center, and would answer every purpose in most cases.

It should be noted in making the second and third copies, that the law requires them to be exact copies of the original. This does not mean equivalent copies; and if the Register does his duty, every figure and word on the original must find its counterpart in the copies.

A form of certificate for the original and the copies can be had from the Auditor General's office. It would save much work if our prepared paper for plats could be had with these certificates printed in black on the sides. I believe there would be demand enough for each form to make the printing of them profitable. I would suggest that our worthy Secretary take the matter into consideration.

Just a word in regard to the appearance and construction of plats, and in this respect I will give you merely my own opinion. In the first place, these are merely maps, and clearness and distinctness should be the first and most important characteristic. The map should not be buried under a mass of pictures and fancy penmanship. The title should be clear and conspicuous, but not too prominent; and it would suit me better if plain. All the lines should be perfectly black, of even width, and thick enough to show well. The street names, figures, and dimensions should be neatly printed in black. I think no ink but a good quality of India ink, should be used for lines or dimensions. Tints can be easily applied, and if of neutral colors, will look well. As to a border, I prefer simply two plain black lines of different weights to any complicated arrangement of chains, vines, etc.

In regard to inks, I merely wish to say that liquid India ink of good quality can now be had. The Higgin's inks are the best prepared in this country, so far as I can find. These may be had in water proof ink for tinting over, or plain for other purposes. A French liquid ink, marked with two dragons, seems to be better than our American inks. The liquid inks are more costly than the stick inks, but are much more convenient to use, especially when no considerable amount of drafting is done.

PROF. R. C. CARPENTER.

HOUSE DRAINAGE.

THE progress of sanitary science during the last decade has been remarkably rapid. This has been largely due to a division of engineering labor and a concentration of the energy of able specialists in this field. No dwelling of any pretensions is now considered complete, or even looked upon with favor by a prospective tenant, unless it is fitted with "modern conveniences." These appliances are entirely proper and safe if the work is entrusted to proper hands. It is hard to conceive of a class of work, however, in which wrong methods or poor work are more detrimental, or the resulting influences more insidious.

In a paper of this kind, little more can be attempted than generalities. Methods of work are largely influenced by particular conditions. The condition of the public sewers, the methods employed for their ventilation and cleansing, and the rules of municipal Boards affecting the citizens, are all to be considered. The tendency at the present time is to refer work of this kind of any considerable magnitude, to specialists.

House drainage in its broader sense means both the removal of the liquid waste and whatever it carries with it, and also the removal of the subsoil water and storm water. Indeed, what is often spoken of as house drainage is strictly house sewerage. House drainage is the removal of water which has not been fouled.

The principal distinction between a sewer and a drain is that the former, being for the conveyance of foul liquid, should be absolutely tight, so that none of the contents may be lost by the way, and no vapors escape. A drain, on the contrary (as for instance a subsoil drain), must be laid with open joints, so that, the pressure being from without, it will receive the ground water all along its course, and remove it. The functions of the two are distinct. When both kinds of drainage are necessary, it is best to keep each system distinct. When a general system of sewerage is already constructed without regard to subsoil drainage, the householder frequently has no option but to connect the drainage system with the sewer proper. A very good method in such a case is to make the connection

through the medium of a deep seal trap where the street sewer enters the house. This connection should be through an iron pipe, properly calked into the trap, and provided with a brass-seated check valve which will prevent the sewage from filling the subsoil drains, in case the street sewer becomes obstructed. The subsoil drains should be of small agricultural tile laid well below the cellar bottom, and the joints properly protected. The sides and bottom of the cellar or basement should be thoroughly damp-proof. I am aware that this point is generally overlooked. We do not stop to consider that the earth below and about buildings is a great collector and retainer of filth, and that it is sufficiently porous to admit of the passage of air currents in considerable volume, especially under the influence of furnace draughts or other like causes. The action is not unlike what would occur if we suppose the house to be set on a sponge 50 x 100 feet, for instance, to which we constantly apply a stream of foul liquid, and then induce upward currents through the house by the action of heat. The cellar walls and floor can be very easily and cheaply made damp-proof and air-tight by a coating of some preparation of asphalt.

The main drain for ordinary dwellings should be four inches in diameter, and laid with as much descent as possible. The inclination should not be less than one in fifty. The method of connecting the main drain with the soil pipe depends upon the method of ventilation. The simplest method is to extend the main drain upward and out through the roof, unbroken by a trap in any portion. In this case it serves the double purpose of soil and ventilating pipe, and the air which passes into the street sewers at man-holes supplies the draught upward along the street sewers, and out through these and their upward extensions. In this case, the isolation of the interior of buildings from sewer air depends solely upon the trap under each fixture. Where street sewers are properly constructed on the "separate" system, and properly cared for, this method has proved entirely satisfactory. It certainly has great advantages in simplicity and facility of arrangement.

Where the sewers are built on the combined plan, the method of isolation shown in Fig. 1 is to be preferred. This diverts the foul air currents from the interior pipe, and provides a supply of fresh air for the upward current through the soil and ventilating pipe. If the street sewers are not properly ventilated at frequent intervals, either by the upward extension of exterior or interior unobstructed pipes or otherwise, there may be reasons for believing that an isolated one may draw from too wide a territory, and prove offensive. In this case, it is advisable to dispense with any vent pipe communicating directly with the sewer.

The main drain within or under the house and for a few feet outside of it should be of iron pipe with lead calked joints. It is better to fasten it along a wall by iron brackets or hangers above the cellar bottom, if possible, giving it as great an inclination as is

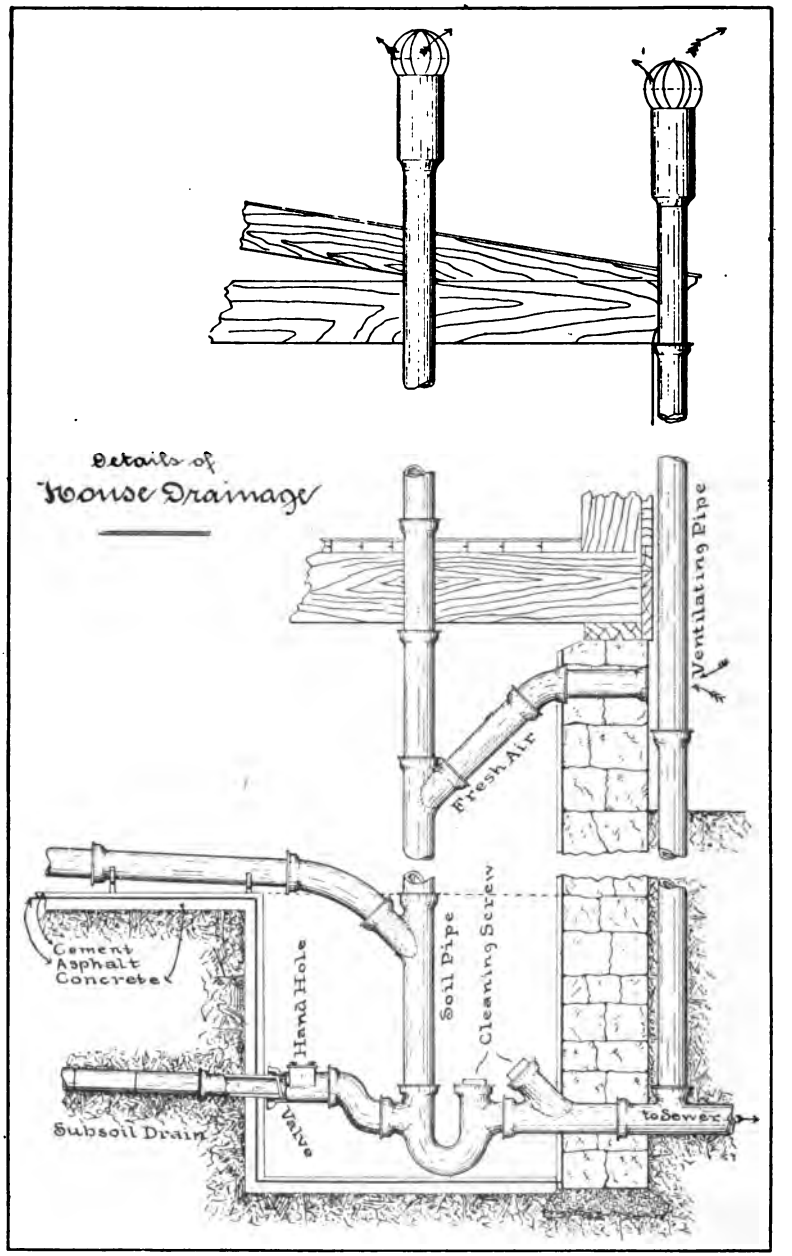
Details of
House Drainage
Ventilating Pipe
Fresh Air
Cement
Asphalt
Concrete
Hand Hole
Soil Pipe
Cleaning Screw
Subsoil Drain
Valve
to Sewer

FIG. 1.

permissible. In some cases it is necessary to place it below the basement floor on account of fixtures in the basement. This should be avoided if possible. Removable hand-holes or brass cleaning screws should be provided at intervals, through which obstructions can be removed. All iron pipes and fittings should be thoroughly coated outside and inside with coal pitch varnish applied hot.

A very common fault is to make the upward extension of the soil pipe, after it passes the highest fixture, of galvanized sheet iron, or even of tin. This is highly objectionable. It should be of heavy iron pipe throughout, and should extend well above the roof. It is a good plan to increase it in size above the roof to six inches, so as to lessen the danger of its being obstructed by the accumulation of frost. Ventilating cowls are of doubtful utility. A plain wire basket to prevent the introduction of articles liable to obstruct the pipes, is better.

There is such a variety of branches, curves, offsetts, traps, etc., etc., now in the market, that there is no excuse for awkward and rough connections and interior projecting angles or pockets which will retain the solid portion of the sewage. The course of all pipes should be as direct as possible, and the fixtures should be grouped so as to be reached as nearly as possible by upright soil pipes and short horizontal soil or waste pipes. Horizontal pipes cannot be carried any great distance along floors or ceilings or between joists, and preserve a proper inclination, for reasons which are obvious. It is customary to make waste pipes, particularly short ones, of lead, for the reason that it is much more easily manipulated than iron. The proper method of connecting the lead wastes to iron is by means of a brass thimble soldered to the lead pipe, and calked into a hub on the iron pipe.

It is a very bad practice to inclose plumbing fixtures with wooden casings, as is done in a majority of cases. It will surely tend to the accumulation of dampness and filth, and the emanation of unwholesome air. Unwholesome smells which are attributed to some faulty construction or arrangement in the drainage pipes, often have their origin in these inclosed spaces.

It is not uncommon in summer, when the air is loaded with moisture, to see water accumulate in bead-like drops on the surface of plumbing fixtures or pipes which are kept cool by a current of water from a tap, and course downward almost in streams. If the fixtures are not inclosed, they can be readily wiped dry. If inclosed, they receive no attention, and the accumulation of dirt and moisture becomes very offensive.

The better way is to have as little wood-work as possible surrounding these fixtures. The better kinds of water-closets are made so as to require no wood surrounding them, except a cover. A very good way to fit up wash-stands is to support the slab upon brackets fastened to the wall, leaving the under side entirely open, and the pipes,

traps, etc., entirely exposed, or partially hid by a narrow slab placed edgewise under the shelf proper, and extending downward about six inches.

So far as possible, it is preferable to have soil, waste, and ventilating pipes exposed, to having them inclosed within partitions, where they are inaccessible either for inspection or repair. This method of arrangement is not without its influence on the plumber. He is not less inclined to pour lead joints properly, or thoroughly to calk them all around, or to make neat and perfectly wiped joints, than when he knows that the carpenter or plasterer will cover his work within a few hours. I am aware that the average house owner will look upon this arrangement as decidedly lacking in finish, and not in harmony with interior decorations. Neither is a stove pipe, a furnace register, a steam radiator, or a gas fixture. This is largely a matter of education, and possibly we have been wrongly taught. It is not customary, however, to place these fixtures in rooms where any exceptions can be taken to this method of arrangement.

Plumbing fixtures should not be placed in sleeping rooms. They should be confined to the bath room, where special means of ventilation can be employed, and to the kitchen, laundry, and similar rooms.

A multiplicity of fixtures should be discouraged. A fixture rarely used is a greater source of danger than one used frequently.

Particular care should be used in arranging the ventilation of a building, so that the air currents tend to pass outward from the group of rooms containing plumbing fixtures, fresh air being admitted to other portions of the building. The facility with which this can be accomplished, and also the proper grouping of fixtures and simplicity of the system of pipes, will depend largely upon the architect. Ample means should be provided for flushing all portions of the soil and waste pipes and all fixtures. This is most effective when special flushing cisterns are supplied.

The ornamentation of porcelain ware and of surrounding woodwork by raised or carved patterns, is positively detrimental. A perfectly plain, smooth, impervious surface is more conducive to cleanliness. A very usual fault in house plumbing is too many fixtures, too much pipe, too much ornamentation. The owner may have perused the sanitary journals, or have heard some sanitary engineer talk sewer gas until he is thoroughly imbued with the idea that *here* is something which must be done thoroughly, and he not unnaturally comes to think that the more extensive the plant, the more sewer gas will be annihilated.

Every fixture should be provided with a trap, and since the object of the trap is to isolate the fouled interior surface of the waste pipe from the air of the room, it is evident that the trap should be as close to the fixture as possible. Notwithstanding many efforts to introduce a trap whose seal cannot be broken by

syphonage, and which will be self-cleansing, the plain-running trap of uniform bore is still in general use. This trap is liable to have its seal broken by syphonage, and to prevent this it is necessary to resort to a back air pipe, which is connected with the crown of the trap on the downward side, and passes to the roof independently of the ventilating pipe proper, or is connected with it above the highest fixture. This back air pipe should be of ample capacity to preserve the equilibrium of air pressure.

The system of back air vents is open to the following objections: It considerably complicates the system of piping, especially where fixtures are not closely grouped. There is a possibility of the pipes' being fouled at their junction with the crown of the trap. It adds considerably to the expense.

Back air vents tend to increase the interior circulation of air considerably. This is beneficial, so far as purity of the interior of the pipes is concerned, but it also increases the evaporation from traps. This will do no harm if fixtures are in constant use. On the other hand, if special anti-syphoning traps are used, and back vents are dispensed with, there will be little circulation of purifying outer air through the waste pipes.

When the soil, ventilating, and waste pipes are all in position, and before the fixtures are put in place, a test of the thoroughness of the work should be made. This can be done in a variety of ways. The following will be a very good test: Close up the main drain where the iron pipe terminates outside the house wall, also the exposed ends of all pipes where fixtures are to be connected, and the fresh air inlet, if there is any. The ends of lead pipes should be left somewhat longer than necessary, so that this can be conveniently done by flattening them, and closing with solder.

When all openings in the entire system of soil, waste, and ventilating pipes are tightly closed below, fill the entire system with water from above nearly to the top, and mark the hight at which the water stands. If no leakage is apparent, and the water stands at the same level for some hours, the joints may be considered good. The entire work should be carefully inspected while under pressure, and joints re-calked where necessary.

It is not proper to connect waste pipes from refrigerators or safes, or overflow pipes from water tanks or cisterns, directly with the sewers or waste pipes. The discharge from these can be often collected at a common receptacle, however, which is isolated from the sewers by special means.

For the purpose of getting a more comprehensive view of what we have sought to accomplish, let us review it briefly.

In the first place, we have secured a dry basement. This we have not accomplished by the ordinary method of an inlet into the sewer direct from the floor through a trap which is generally empty and provided with a removable strainer, which some servant will displace, and quite likely lose. On the contrary, instead of mak-

ing a hole in the basement floor, so that if it gets full of water, it can run out again (some day), we have sought to keep the level of ground water so low that the tendency will be in the other direction. It is well to design work of this class on the supposition that the worst will happen. Let us apply a few tests of this character, and note the probable behavior of our appliances. Assume, for instance, that it rains and continues to rain until the ground water rises considerably above the basement floor. The tile drains will remove it as rapidly as possible, and (the basement walls and floor being assumed impervious) there is no avenue by which it can enter. There is no trap or valve interposed, by the failure of which such an avenue can be established. The water-proof coating extends not only over the basement floor, but into the trap chamber, and surrounds the traps and soil and vent pipes like a dentist's rubber dam, entirely isolating the interior from whatever may be without. (See Fig. 1.) We may ride out the storm with all the confidence of a seaman in a dry ship. Suppose, again, that the main drain outside the house or the street sewer becomes obstructed. In this case, the tendency will be for the sewage to accumulate in the main drain and soil pipe, and be distributed and diffused through the subsoil drains. Its ingress to the subsoil drains will be prevented by the check valve. Suppose, however, that the check valve does not act, and that sewage is diffused through these drains. The house is still entirely isolated from it by an air-proof coating, and the danger reduced to a minimum. The check valve is readily accessible for inspection by removing a hand-hole, and its failure is not probable. If the stoppage remains unnoticed for some time, it will overflow at the lowest fixture, if there is one in the cellar, and if not, probably it will overflow at the fresh-air inlet outside, if there is one.

If the pipes or traps become obstructed, they are all readily accessible without damage to partitions or floors.

I recall an instance where a party built a ten-inch main drain for a small house which would have been amply served by one of four inches in diameter. An untrapped pipe was left open at the basement floor, so that water might not accumulate in the basement. The wisdom of this procedure became apparent later when the house was completed, and it became evident that the main drain and the cold air duct supplying the furnace had been combined. A pipe four inches in diameter is too small for this purpose. The system outlined in Fig. 1 makes no pretensions to a "general purpose" utility.

If roof water is admitted directly to the sewers, the rain-water leader should connect with the main soil pipe directly above the main trap. No waste or soil pipe should be connected with the rain-water leader. In a great many cases it will be advisable not to discharge the roof water into the sewers, particularly in the case of isolated dwellings where a portion of it is retained by cisterns,

and where lawns are of considerable extent. In the case of more compactly built city buildings, it will often be best to allow the roof water to be discharged into the street gutters, especially where these are properly arranged, and the descent is sufficient.

The following table of the behavior of house drains when running three-fourths full, was calculated by Robert Moore, C. E., of St. Louis, Mo. : —

TABLE OF DIAMETERS OF HOUSE DRAINS.

With various grades, and for lots of different sizes, capable of discharging two inches of rain per hour, when running three-fourths full.

Calculated by Robert Moore, C. E., St. Louis, Mo.

SIZE OF LOT IN FEET.	FALL PER 100.						
	1.0	1.5	2.0	2.5	3.0	4.0	5.0
	DIAMETERS IN INCHES.						
20 x 150	3½	3½	3	2⅞	2¾	2⅝	2½
25 x 150	3¾	3½	3¼	3⅛	3	2⅞	2¾
30 x 150	4	3¾	3½	3⅜	3¼	3	3
35 x 150	4¼	4	3¾	3⅝	3½	3¼	3⅛
40 x 150	4½	4¼	3⅞	3¾	3⅝	3½	3¼
45 x 150	4¾	4⅜	4⅛	4	3⅞	3⅝	3½
50 x 150	5	4½	4¼	4⅛	4	3¾	3⅝
60 x 150	5⅜	4⅞	4⅝	4⅜	4¼	4	3⅞
70 x 150	5⅝	5¼	4⅞	4¾	4½	4¼	4⅛
80 x 150	6	5½	5¼	5	4⅞	4½	4⅜
90 x 150	6¼	5¾	5½	5¼	5	4¾	4½
100 x 150	6½	6	5¾	5½	5¼	5	4¾

By an inspection of the table, we see that a four-inch main drain is ample for any ordinary condition of service, even if roof water be admitted, the discharge of house sewage proper being only a very small percentage of the total volume. A smaller size than four inches is not to be recommended, however, for the reason that although it may be ample so far as estimated carrying capacity is concerned, it is more liable to obstruction. Under some circumstances, it may be advisable to increase the size of the main drain to five or even six inches' diameter; this limit should not be exceeded, however. If one drain of this size is not ample, it is better to increase the number.

GEO. S. PIERSON.

President. — "I suppose that this contemplates an abundant supply of water, and pressure sufficient to cause all these sediments to disappear; but I think for a common place or farmer's house, such as we generally find throughout the State of Michigan, there would be no greater convenience than to be able to take

away the kitchen slops without injury to the room and without the necessity of going out-of-doors."

Mr. Foster. — "The trouble with the kitchen slops and all that kind of stuff is that you can have good tiles and drains, etc., but they will get stopped up every time. I have tried a great many plans, but I think I have never been fortunate enough to find anything to displace the old 'slop pail' successfully."

Mr. Appleton. — "I think the best way is to take it out in a pail, and throw it out on the ground, scattering it over a considerable area, not throwing it into heaps."

Mr. Watkins. — "I have no system of house sewerage on my place, but I have a pail, and when it gets full, I carry it to the garden gate and throw it onto the garden, and every rain that comes washes it over the ground, so that there is never any bad odor arising from it."

Mr. Foster. — "In the city of Nottingham, Eng., they pump it up to the top of a hill, where it is distributed all over the adjacent country; and I can just tell you the crops they raise on those grounds would surprise you, the system keeping it enriched continually."

Mr. Appleton. — "And I would just say that is a pretty good paying thing, as it is not so expensive as one would naturally think it to be."

Mr. Wells. — "In small sewers, where the obstruction is caused mostly by the grease sticking to the pipes, I find that by pouring a little ammonia into the pipe occasionally, it will keep it clean."

Prof. Greene. — "If you will stir up a half pail of ashes with some water, and let it stand awhile until there is some strong lye, and pour that into your pipe, you will find it will clean it out pretty effectually."

Prof. Cooley. — "We have made a practice of spreading our coal ashes over our slops after being thrown into the back yard, and I have never noticed any odor from them."

APPLICATION OF PHOTOGRAPHY TO SURVEYING AND ENGINEERING PURPOSES.

To the President and Members of the Michigan Engineering Society :—

THE recent progress in photography has made it an indispensable aid in nearly all of the arts and sciences. In engineering and surveying, it should receive attention as one of the most important means of improved practice in field work, until the camera is as familiar to the profession as the compass and transit.

But a few years ago the practice of photography in the field was limited to exceptional conditions, on account of the cumbersome outfit required, and the tedious processes involved in the

preparation, exposing, and developing of the wet plates used, on the spot where the observations were made. The skill of the professional photographer was, in fact, required to obtain satisfactory results.

These difficulties disappeared with the invention of the modern dry plates, which can now be procured at reasonable prices; and the best results can be secured with the exercise of ordinary skill, while the records obtained in the field can be kept indefinitely before developing, which may be done at home, in the evening, or during any convenient interval of leisure. The lenses used in the portrait galleries are unsuited for such work, as they give a distorted image that does not permit a quantitative comparison of the different parts of the field of view.

Aside from the camera and lenses which are needed for accurate work, but little apparatus is required, and that simple and inexpensive.

So far as the wants of the engineer or surveyor are concerned, the art of photography can now be learned in a few days' practice, if reasonable attention is given to a few simple details of manipulation.

Dry plates are now made so sensitive that good results may be obtained with even a moderate amount of light. Interiors and foundations may now be photographed at night by means of the magnesium light, as readily as in the most favored localities in broad daylight; and it is even difficult to imagine conditions that would prevent the satisfactory application of the art.

There are many applications of photography that will be readily suggested to the practical engineer. Aside from the copying and enlarging or reducing of maps and plans, by means of bromide paper prints, or the blue print process with which you are all familiar, we will ask your attention to the relation of photography to field work. In engineering constructions and buildings, a record of every detail of the work, from foundation to completion, can readily be made. The value of such permanent record in checking estimates, or in the study of any special features of the work, can hardly be overestimated. It is important that the photographic record should be made by the engineer himself, so that the strict conformity to a scale may be clearly observed. Without further examples, the utility of photographic methods of recording the progress of constructing details, must be fully appreciated.

In surveying, it will at once be suggested that a photographic record of monuments with their surroundings, will be convenient for future reference, and in cases of disputed boundaries, may be valuable as evidence. The latest applications of photography in topographical surveying are, however, of the greatest interest, as the new method of field work with the camera has the advantage of making a perfect record of every detail of the field surveyed,

while it furnishes the required data for a map on a horizontal plan, with an exact representation of every elevation and depression.

The mathematical and mechanical principles involved in photographic surveying were discussed by Col. Laussedat, of the French Engineers, as early as 1858, and they were soon afterwards applied under the disadvantages of the old wet plate process with remarkable success. In 1864, M. Javary made a photographic survey of Grenoble and suburbs. It agreed closely with the regular survey made by the engineer in charge of roads and bridges, the differences in level nowhere exceeding 19 inches.

Meydenbauer, in Germany, about the same date, "made a photographic survey of Fribourg and suburbs, plotting to a scale of $\frac{1}{1000}$ with ten-foot contours. The field work required two days; there were six stations and twenty-one plates; the plotting required eighteen days, and the resulting map was accurate in every respect. In 1874, M. Javary made in one day a photographic reconnaissance extending fourteen miles, and embracing the features for a distance of from one to two miles on each side of the route. And on another occasion he executed in fourteen hours the field work and plotting of a complete and exact map, including the leveling of a zone three-fourths of a mile in breadth; and this in rainy weather, and with wet plates."

Experiments made in 1878–80 brought the gelatine-bromide emulsion plates into notice, and since that time the process has been perfected and brought into general use. These dry plates are exceedingly rapid, and the simple manipulations required in their use leaves nothing to be desired in their applications to photographic surveying. In 1887, Lieut. Reed, of West Point, "made, with dry plates, a photographic survey of a tract containing about twenty-seven square miles; three principal and two auxiliary stations were used from each of which four or five views were taken. The field work occupied ten hours; and with a little more previous experience, the plotting, including the leveling, could have been readily performed in two or three days. For the leveling, about 100 points were determined from the views, and most of these points, in plan, construction, and leveling, checked exactly." According to Col. A. C. M. Pennington, U. S. A., in surveys made by this method in Savoy, "one survey of eighteen days' field work sufficed for 30,000 acres, contour lines being mapped five meters apart, giving five months' office work. In another case 110 proofs were taken for 20,000 acres, the field work consuming but fifteen days."

The advantages of this method of surveying are obvious. While the work is rapidly performed, there is a complete record of every detail of the field in both plan and elevation, so that accuracy is secured, under a multiplicity of checks against possible error.

The leading principles involved in this method of surveying may be briefly stated as follows: A landscape photograph, if made with a rectilinear lens, is a true perspective, in which right lines are shown as right lines, and curves as curves, each in due and fixed proportion to the original.

When the picture is taken, the camera must be carefully leveled in two directions, and a vertical plane through the optical center of the lens may be taken as a base line from which the angular distance of any point may be measured in a horizontal direction.

A horizontal plane in like manner projected through the optical center of the lens may be taken as a horizon from which the angular distance of each elevation and depression may be determined.

The key to these angular distances, either horizontal or vertical, is the equivalent focal distance of the lens combination, which must be carefully determined, and taken as radius in measuring the angles, by a protractor or a table of natural tangents.

It has been recommended in actual field work to measure a base line, from each end of which the entire field to be surveyed can be seen. From the ends of this line the bearing of several points in the field that can be identified on the photograph, may be taken with the compass, and this will serve as a skeleton plan when placed on paper, to aid in the plotting.

Two or more views should be taken with the camera from each end of the line, as it is necessary that each point of the field should appear on at least two plates. In plotting, the ordinary method of intersections is applied in fixing points on the plan, very much as in plane table surveying.

It is unnecessary to go into details in regard to field work and plotting, as these will be fully described in the works you will need to consult in applying the method in practice.*

Special forms of the camera have been devised for photographic surveying, but on the whole, the common camera will probably be the most satisfactory. It should be well made, with a rigid vertical front and back, so that the optical center of the lens will always coincide with the same point on the focusing screen. A "rising front" will be found convenient in adjusting the optical center of the lens to the wire that serves to record the horizon. The camera should revolve on a spindle fixed to the top of a tripod with leveling screws. A round disk of board, with graduated edges, fixed to the top of the tripod, will be found con-

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* References: "Photography Applied to Surveying," by Lieut. H. A. Reed, West Point, John Wiley & Sons, 15 Astor Place, New York. 4to; cloth, $2.50. This is probably the best and most comprehensive work on the subject.

"Topographical Drawing and Sketching," including applications in photography. Same author and publishers. $3.50; new edition, $5.00.

An article by Lieut. Reed, on "Photography Applied to Surveying," and another by Col. A. C. M. Pennington, U. S. A., on "Photography Applied to Military Purposes," printed in "Authony's International Annual." Paper, 50 cents; cloth, $1.00.

venient to indicate the angle from the base line at which the view is taken.

A fine horizontal wire should be placed in the plate-holder, in the plane of the optical center of the lens, so that it will be in contact, or nearly so, with the plate when exposed, and thus record the horizon from which elevations and depressions are measured. A fine vertical wire in the plane of the optical center of the lens, and similarly placed in relation to the plate, will also be of assistance in orienting the views on the map.

A detached level will serve in adjusting the camera, which must always be leveled in two directions when the views are taken. Accuracy in all of the adjustments, as in the case of other engineering instruments, is essential to exact work.

As to the size of the camera, no definite rule can be laid down, as much depends on the character of the work. The larger plates are of course more cumbersome, and they not only cost more, but are also more difficult to manipulate. On the other hand, they have the important advantage of giving the views on a larger scale, so that greater accuracy may be secured in measuring and plotting.

Cameras for 5 x 8, 8 x 10, or 10 x 12-inch plates may be used, but the first mentioned is too small for any but limited areas. Taking everything into consideration, my impression is that 8 x 10 plates will be found most satisfactory for ordinary field work, and the camera for this size of plates need not be so heavy as to be objectionable on that account.

Only the best lenses should be used, and these must be of the rectilinear type. The ordinary portrait and landscape lenses give a distorted image that is not noticed in a portrait, but which entirely unfits them for architectural work or field surveying. It will be poor economy to buy a second-class lens, even if it is rectilinear, as it will fail to give the best results under unfavorable conditions of light. The lens must of course be adapted to the camera and the size of plate used, and as a general rule, its equivalent focal distance should somewhat exceed the longest diameter of the plate.

A lens of shorter focus, or a wide angle rectilinear lens, may be needed in circumscribed localities, where the long focus lens, best adapted to field work, cannot be used.

The equivalent focal distance of each lens should be accurately determined, as this is an essential factor in plotting from the negative.

There are many brands of dry plates now in market, and there is but little choice among the leading makers, as Stanley, Carbutt, Seed, etc. It will, however, be best to use but one kind, as each brand has its peculiarities in regard to development and exposure, and when one becomes thoroughly acquainted with the behavior of his plates under different conditions, he can obtain the best

results from them, when he might fail with a new brand that needed slightly different treatment.

Of the many developers now in use, the new hydroquinone will undoubtedly prove the best for all purposes, and it can now be obtained at a price that makes it the cheapest, as well as the best.

With a little experience, many applications of the art will suggest themselves. For example, a true meridian may be readily made with the camera. On a bright, star-light night, the camera may be carefully leveled and pointed approximately north, and a rapid plate may be exposed for several hours. The circumpolar stars will describe arcs on the plate, and the landscape beneath will also be copied. When the centers of the arcs are graphically determined, and radiuses drawn from them, the radius that is vertical will be on the true meridian, and it may be produced to indicate the required point on the landscape.

For photographing foundations or interiors, or copying at night, a magnesium flash light may be used with rapid plates.

DR. MANLY MILES.

DESIGN FOR PIER ON SOFT GROUND.

THERE are nearly 14,000 linear feet of timber pier at the St. Mary's Falls Canal. About one-third of the pier was built in place when the water was out of the canal, and the remainder was built in the form of cribs, and then sunk in place. Four spuds, one at each corner of a crib, being used to keep it in alignment, and the top nearly level, a continuous superstructure four feet high was built on the cribs.

No trouble was had in regard to a solid foundation, as the greater portion of the piers rests upon sandstone, bedrock, or hardpan, the principal exception being a section of the pier 200 or 300 feet long a short distance above the lock. After the excavation had been made for the pier side, there still remained a pocket of quicksand from two to seven feet deep on the sandstone rock, over which a line of continuous pier was built in place in March, 1881.

The method adopted was simply that of placing a platform of two-inch planks, six feet long, transversely under the front and back walls of the pier, and in order to allow for settlement, the planks were placed about four inches above grade. At present it is from one to three inches lower, but its alignment is as good as that of the adjoining piers. Last year the construction of the pier in front of Fort Brady military reservation having been determined upon, plans and specifications were prepared.

A shoal extended about 150 feet in front of the line adopted as the face of the pier. On the pier site the depth of water varied from two to twenty-nine feet. The material of the shoal was composed of silt, quicksand, and stones, and over 32,000 cubic yards were removed to a depth of twenty-one feet by dredging.

The location is such that there will be no heavy seas to withstand, so that in order to provide a proper foundation for securing stability and permanence of the cribs, it was only necessary to consider the pressure against it as a retaining wall, and the blows it might receive from passing vessels. It is possible that the pier and the area back of it may be used for a stone-yard during the construction of the proposed new lock.

The general plan of the crib is a modification of those forming the breakwater at Chicago and other Lake Michigan harbors. The principal changes are in the method of framing the ties, and in arranging the bottom course so that the side walls are directly over the bearing piles, thus making a somewhat stronger form of crib.

The cribs as designed are fifty-six feet long, twenty feet high, and twenty feet wide, except the bottom course, which is twenty-two feet wide. The timbers for the two upper courses of the cribs and the four courses of superstructure are to be of white pine, and that for the rest of the crib will be of hemlock. Each crib rests on fifteen bearing piles. To insure a true bearing on the piles, the bottom is made of three horizontal surfaces, each three feet wide, extending the full length of the crib, and corresponding in position to the rows of piles.

The cribs are built with tight sides. The cross walls are eight and one-half feet apart, each alternate one being solid, and the others with a foot of open space between the ties. Half way between the cross walls are grillage timbers at top and bottom. The timbers are twelve inches square, and carefully framed and firmly bolted together. The open bottom of the cribs allows the stone filling to pass through and form a solid base for the cribs to rest upon; and additional stability is given by triangular-shaped pockets in the end compartments; the apex of the triangle being down and next to the end walls.

Stones will also be placed in front of the pier to a hight of one foot above the top of the piles.

The contractor for excavating the lock pit will be required to fill the area between the pier and the shore line up to the level of the top of the pier. For a distance of twenty-five feet back of the pier, the filling must be of stone. The bill of materials for one crib is as follows: —

WHITE PINE. — IN SUPERSTRUCTURE AND UPPER TWO COURSES OF SUBSTRUCTURE.

1	piece	timber,	1 x 1 x	34	feet	34 cu. ft.
10	"	"	"	32	"	320 "
3	"	"	"	30	"	90 "
2	"	"	"	26	"	52 "
15	"	"	"	24	"	360 "
1	"	"	"	22	"	22 "
35	"	"	"	20	"	700 "
16	"	"	"	16	"	256 "
2	"	"	"	14	"	28 "
	Total					1,862 "

HEMLOCK. — IN SUBSTRUCTURE.

4	pieces	timber,	1 x 1 x	34	feet	136 cu. ft.
21	"	"	"	32	"	672 "
10	"	"	"	30	"	300 "
10	"	"	"	26	"	260 "
30	"	"	"	24	"	720 "
17	"	"	"	22	"	374 "
64	"	"	"	20	"	1,280 "
28	"	"	"	18	"	504 "
30	"	"	"	16	"	480 "
8	"	"	"	14	"	112 "
	Total					4,838 "

IRON.

557	drift bolts,	1″ ○ x	34″,	wt.	$7\frac{52}{100}$	lbs. 4,189 lbs.
39	" "	1″ ○ x	22″,	"	$5\frac{16}{100}$	" 201 "
28	screw and washer bolts		$1\frac{1}{4}$″ ○ x	39″		368 "
7	" "	" "	$1\frac{1}{8}$″ ○ x	27″		69 "
	Total					4,827 "

15 piles, 32 to 45 feet in length.

The specifications are as follows : —

DESCRIPTION OF WORK. — The work to be done under these specifications comprises the construction of about 1,460 linear feet of pier. For this purpose the contractor will be required to furnish about 34,000 cubic feet (more or less) of white pine timber, and 96,000 cubic feet (more or less) of hemlock timber, 390 piles (more or less), and 89,000 pounds (more or less) of bolts; also to drive and saw off to grade 390 piles (more or less), to frame and place in the pier about 175,000 cubic feet (more or less) of pine and hemlock, and to fill the pier with about 22,000 cubic yards (more or less) of stone.

LOCALITY. — The pier is to be placed in the St. Mary's River, in front of Fort Brady, Mich. A dredge, cut in which there is about twenty-one feet of water, has been made for the pier site.

CONSTRUCTION. — The pier will consist of wooden cribs built separately, then placed on a pile foundation, and filled with stone; next, a continuous superstructure will be built over the whole length of the pier; and, finally, the pier will be filled to the top with stone. Drawings illustrating the location and construction of the pier may be seen at the U. S. Engineer office at Detroit or Sault Ste. Marie.

The piles must be in the places indicated in the drawings, and they must be driven until a hammer weighing 2,000 pounds and falling fifteen feet will not drive the pile over one-half inch. After they have been driven, they must be sawed off so that their tops will be in a horizontal plane seventy-eight and one-half feet above canal datum (which corresponds to a depth of water of twenty feet). The top of each pile after being sawed off must be within one foot of the place indicated in the drawings. If any settling occurs after the cribs have been placed on the piles, leveling pieces, cut and framed to dimensions furnished by the United States agent in charge, must be added before the superstructure is built.

The ends, and the length of the two cribs at the northwest angle, may be varied. Special drawings will be furnished for these cribs and their superstructure.

FRAMING AND BOLTING. — The manner of framing and bolting, the position of ties, etc., must be as shown in the drawings (except that at the option of the United States, the upper six courses of the pier may be varied so as to give a batter of six inches). The workmanship of the framing and bolting of all parts must be as good as the best work of the existing piers of St. Mary's Falls Canal.

The diameter of the holes for the drift bolts must be one-eighth of an inch less than the diameter of the bolts, and the holes must be bored the whole distance that the bolts are to be driven.

PLACING CRIBS. — Each crib must be so placed on the piles that no point in its face shall be more than two inches out of alignment, and that the space between the ends of the cribs shall not be greater than one foot.

FILLING. — The cribs and superstructure must be filled to the top with closely-packed stones.

MEASUREMENTS. — The timber, piles, and bolts furnished by the contractor will be measured and estimated on delivery. The framing will be estimated by the cubic foot as measured after being framed and bolted in the pier. The stone filling will be estimated by the cubic yard after it is deposited in the pier.

ORDER OF WORK. — The order in which the work shall be prosecuted will be determined by the agent of the United States, whose instructions in all matters relating to the work must be conformed to by the contractor and his employees.

TIME. — The piles must be driven (through the ice) before the 15th of April, 1889. The remaining work must be begun before

June 1, 1889, and completed before Nov. 1, 1889. From the beginning, the monthly rate of progress shall be, at least, equal to the average monthly rate required to complete the work within the specified time.

GENERAL REQUIREMENTS. — Any timber, iron, or material of any kind, unnecessarily wasted by the contractor, will be charged to him, and deducted from his next succeeding estimate. Any stone or other material dropped into the canal or about the pier, by the contractor, must be removed by him without cost to the United States. No extra work of any kind will be paid for, unless specially ordered in writing. All drawings cited in explanation of these specifications are considered to form a part thereof.

TIMBER. — The white pine timber must be sawed accurately, free from splits, shake, rot, blackknots, wane, or other imperfections.

PILES. — The piles must be of hemlock, or other equally suitable timber; they must be straight and sound, and at least ten inches in diameter at the smaller end.

IRON BOLTS. — The drift bolts are to be made from an approved quality of round iron, one inch in diameter, blunt pointed, and with round heads one and one-half inches in diameter. The screw and washer bolts are to be of similar round iron one and one-eighth inches in diameter. (A drawing will be furnished the contractor, showing the form of all the bolts.)

OFFERS. — Bidders must state the price per unit for the several classes of materials and work separately, but the aggregate, determined from the pieces and the approximated quantities, *will* be considered as one bid.

PAYMENTS. — Payment will be made monthly, reserving ten per cent from each payment until the completion of the contract.

There were eleven bids received; the lowest and highest being as follows: —

	White pine timber.	Framing white pine tim.	Hemlock timber.	Framing hemlock timber.	Furnishing piles.	Driving piles.	Drift bolts.	Stone filling.
	cu. ft.	cu. ft.	cu. ft.	cu. ft.	each.	each.	per lb.	cu. yd.
Lowest Bid	.24c.	.07	.13⅓	.07	$3.00	$4.00	.03c.	.48
Highest Bid	.30	.05½	.20	.06½	4.50	4.00	.07	1.50

Rate per linear foot of pier, $39.55, and $64.38 respectively.

JOSEPH RIPLEY.

MEASUREMENT OF A PRIMARY BASE.

In 1841 was begun what has since turned out an immense, complete, and most satisfactory work; namely, the survey of the great chain of inland lakes of North America, by the United States Government. It was carried on for forty years, the final charts not being out until 1881. The work was under the charge of the War Department, the immediate supervision being, at first almost exclusively, in the hands of Corps engineer officers, but later, as the scope of the work enlarged, and more engineers were necessary than could be spared from the Corps for this purpose, civilian assistants were added. Many of these latter were with the survey for years, and to some of them is due especial praise for the methods and suggestions in carrying on the work, in particular, the wonderfully careful result in Base Line work, shown in the Reports of E. S. Wheeler, who now, by the way, has charge of the Government work at the "Soo," under General Poe.

Previous to 1852, when for the first time our Government published three charts of parts of Lake Erie, there was absolutely nothing in the way of printed help for American Sailing Masters; for although even before this time, Bayfield, of the Royal British Navy, had done a great deal of really fine work in data for accurate charts, considering the rough methods and rapid reconnaissances that he in person must have made to cover the ground and water that he did, and in the time he did, these were not allowed out of the hands of the British Admirality, and our brave navigators of even up to a few decades back, knew best where a sunken rock was when it had punched a hole in their wooden bottoms.

The survey was started under a Government appropriation of $15,000, and at a time when a vessel leaving Chicago found no shelter until reaching the Manitou or Beaver Islands, and after passing the Straits of Mackinaw and Presque Isle, no harbor, until considered safe in St. Clair River. Even then she had to pass the dangerous fishing "Flats" before she reached our goodly city of Detroit.

With one exception (1847), Congress made yearly appropriations of sums varying from $15,000 the first year, to $175,000 each year from 1871–74. In the aggregate, for the forty years, and until the survey was completed, the appropriations amounted to $2,927,000. That this sum was in the main honestly and carefully spent, can be seen in the published charts, for they are as full and as complete as can be desired, and on them one can measure 6,000 miles of shore line. Thus for less than $500 per mile was the great survey made, and at an average rate of 150 miles per year. This is an odd way of figuring up such work, but still it is pertinent.

From the start, a general Geodetic Survey of the entire chain of lakes was contemplated, but owing to the meagerness of the ap-

propriations during the earlier part of the work, the actual operations were confined to localities where improvements were called for, or where navigation was specially difficult. Thus the small moneys were expended for preliminary surveys at these particular localities because of the pressing need of improvements, and the purchase of larger and finer instruments necessary for the more extensive and exact work was deferred for many years. These instruments, finally obtained mainly through the efforts of Gen. C. B. Comstock (who had charge of the survey from the spring of 1870 until its completion in 1881), were as fine as the world could produce. The Bache Wurdeman Base Line Apparatus, however, which I wish particularly to describe, and to which is due the exactness of the work, even to the determination of questions as regards the precise form of our world, was purchased as early as 1852, when Capt. J. N. Macomb was in charge.

It was constructed by Mr. Wm. Wurdeman, of Washington, under the direction of Capt. Thos. J. Lee, of the Topographical Corps, and was in all essential particulars similar to that made the previous year for the coast survey, but modified for the purpose of being lighter, smaller, and more delicate.

It is a contact apparatus, the measurement being made with two tubes, each consisting of an inclosed tin case containing two bars, one of iron and one of brass, firmly joined together at one end, and carrying at the other a compensating lever, so constructed that the tube shall have nearly the same length at all temperatures. The bars are each 168 inches long, the iron, 1.40 inches high and .27 inches wide, is immediately over and three tenths inches distant from the brass one, which is 1.10 inches high, and .37 inches wide. To the front end of the brass bar is hinged a vertical compensating lever, having on its rear side a knife edge which is pressed by a spring against a steel plate on the front end of the iron bar, while higher up another knife edge on the front face of the lever has constantly pressed against it a sliding rod, whose forward end, armed with an agate plane, projects from the front of the tin case, and forms one measuring end of the tube. The object of this lever, made as it is with the distances of the knife edges from each other, theoretically determined to correspond with the expansion of the two different metals, is to make the distance between the end points of the tubes during changing temperatures, constant, so long as the two bars have the same temperature. At the rear end of the tube, a vertical arc for measuring inclination is fixed to the upper bar, and is read by a vernier with a level on its arm, called the sector level, the horizontal axis of the vernier being perpendicular to the plane of the bars. The vernier arm carries a small cylindrical surface, the axis of which coincides when in adjustment with that of the vernier, at the instant the bubble of a small contact level moved by the same arm bearing the cylindrical surface, plays. Against this surface abuts

a brass rod, armed at its outer or rear end with an agate knife edge, and, projecting through, forms the rear measuring end of the tube. In guides, this rod has an end motion only, and when the tube is not in contact with its mate, is forced out by the counter balance on forward end of contact level. In measurement, the base line, which for primary triangulation is chosen on ground as near level as possible, and from four to six miles long, is carefully marked by stakes, and these stakes by scratches obtained by a theodolite placed in the vertical plane passing through the ends of the base line. The first tube is placed in line (by means of two theodolites) on carrying trestles, which in turn rest on iron pins, driven into the ground. The rear trestle has three legs, and is provided with a tri-rectangular head motion, while the forward one has only two legs, with head arranged for only a vertical and cross motion. By one of these slow motions on the rear trestle (the longitudinal), the tube is brought into place, so that the rear agate knife edge is, when forced in until the contact bubble plays, exactly over the minute marking on the metal button, firmly leaded into the base line end stone. This is done by the help of a theodolite placed at right angles to the base line. The second tube is now brought into place, the rear end by the various motions of the trestle head made ready for contact, and the forward end adjusted in line by a theodolite ahead. Contact is made by the longitudinal slow motion, the rear knife edge of the second tube being forced against the rigid plain agate in the front end of the first tube, until the contact level plays. Then the contact level, the sector level, the sector arc, and three very delicate thermometers inside of the ends and center of the tube, are read by two independent observers. Contact is then broken, the rear or first tube with its tent being brought back away from the second, and carried around and again aligned in front of it, and the work continued. To facilitate this, an extra set of trestles are used, to provide for there always being a set ahead in which to place the next tube. The iron pins on which the trestles stand are properly driven and leveled by means of trial bars corresponding to about the positions the trestles will have to take when holding the tube.

In order that no direct radiation of the sun may affect the tubes, portable frames, covered with canvas, and large enough for the observers to work under, are at all times carried over each tube. When, at night for instance, it becomes necessary to stop work, a theodolite is set up about ten feet from the forward end of the forward tube, and another approximately in a vertical plane through the end of its agate, at right angles to the line. By means of these theodolites, a mark is made directly under the agate, on the head of a copper tack in a stout peg, the top of which is driven below the surface of the ground. The stability of this mark during the cessation of work is checked by other similar marks, placed in a line perpendicular to the base line. The record is kept in duplicate by

two recorders, also all readings, accompanied by observations of the state of the weather, cloudiness, dampness, etc.

In an apparatus like the above described, composed of so many parts, and liable to change length at each of the places of contact, frequent comparisons with a standard are necessary. The standard used was a fifteen-foot brass bar, the temperature being fixed by packing it in ice which was constantly renewed. To determine what the length of the tubes was during the measurement, the comparisons were made under tents, and under circumstances as nearly the same as those of measurement as possible, and continued from 8 A. M. to 6 P. M., so as to include the same diurnal fluctuations of temperature as took place during measurement.

The method of comparison was as follows: —

Two contact level comparators reading to one hundred thousandth of an inch, were mounted on heavy stone piers, a little more than fifteen feet apart. The masonry supports of these piers rested on rock, and the piers were boxed nearly to their tops, to protect them from unequal changes of temperature. A tube resting on its trestles was placed between the comparators, the standard bar packed in ice was placed on top of the tube, and carefully aligned, and then by motions of the trestles, one or the other was brought between the comparators, contact made, and the comparators read, as well as the thermometers in the tubes. In reducing, the thermometers were corrected for their errors, and the readings on the standard bar and tubes plotted as ordinates with times as abscisses. On inspecting the curves made by the plotting of comparisons of tubes with the bar in ice, when temperature was above 65°, slight depressions are seen in the tube curves, arising from the cooling effect of the ice during the five or ten minutes it was on the tube. In extreme cases, these depressions amounted to .00040 inches.

The values of the comparator screws being very carefully determined, the differences between the tube and bar curve give the corresponding differences in length, and hence the length of the tube from the computed length of the bar at the observed temperature. In computing a measured line, every tube length in the several thousand times each was used, had to have these several following corrections applied: —

1. For inclination of tube to horizontal plane.
2. For reading of contact level.
3. For error in sector level adjustment.
4. For error in cylindrical surface above referred to.

The first of these needs no explanations. The second arises from the fact that the tube is at its definite length when the bubble is at the middle of the contact level, and changes by very minute known quantities when the bubble is not exactly in the middle. The third arises from the fact that the sector level is not stable in adjustment. When found, it is assumed to be proportional to the number of tubes measured since the last adjustment. It gives

a correction both to the grade angle and to the tube length. The fourth arises from a slight defect in the cylindrical surface, by which the tube was slightly shorter at *O* inclination than at any other. The sum of these corrections applied to the sum of tube lengths as found for each day's measurement, gives the length of the base.

To form an idea of the accuracy of the measurement of a base line, a portion of the Kewenaw Base, ninety-four tube lengths (about 1,410 feet), was measured over seven times. Deductions from a table of residuals, giving the excesses of the separate measures over their mean, shows a probable error of one measurement to be in .030 inches, or about 1–560,000.

Now again, besides all the corrections above applied, there are a number of others to be looked into before the length of a line can really be said to be obtained. The alignment of tubes which one would think could not be out an appreciable amount, carefully done as it is with theodolites, showed after numerous trials in testing for a lateral deviation from a right line, that, in the Buffalo Base, for instance, it amounted to .024 inches. There is another error entering into every measurement of a tube length, arising from the pressure of contact between consecutive tubes. This pressure, when reduced to the lowest amount consistent with constantly overcoming the friction of the sliding rod, was still four ounces. A tube, for instance No. 2, when brought into line and forced back against No. 1 till the bubble played, followed No. 1 some. No. 1 was in turn brought back away from it, and it was forced farther back when No. 1 was again placed in front of it. The amount of this disturbance varied with the precision with which the movable parts of the trestle fitted into each other, and with the hight to which the tube is raised by the vertical motion of the trestles. The rerults, from a hundred determinations of the amount of this displacement when pressure was adjusted to about four ounces, gave a mean of .00034 inches when the trestle was at its maximum hight, and .00013 inches when the trestle was down.

In the Buffalo Base, when the hight of the trestles averaged seven inches, and the line contained 1,483 tubes, the correction amounted to .69 inches. The last correction is to reduce the length as measured, to that of mean ocean tide level at New York. The Buffalo Base, levels of which were taken to and from Lake Erie, distant six miles, by the writer, and with results which happened to differ in the two measurements by less than one-tenth inch, showed it to be 35.7 feet above mean lake level, and mean lake level being 573.6 feet above New York tide, gave the Base an altitude of 609.3feet, making the correction for tide level a reduction of 7.77 inches.

The Buffalo Base Line as measured, with all corrections applied. and with decimal places beyond hundredths stricken out, is given at 266,966.61 inches.

Triangulation, carried over from the Sandy Creek Base at the other end of Lake Ontario, and distant two hundred and ten miles (measured similarly, and a year before), only differs from the above result by 1.44 inches in the computed length of the base line, or a discrepancy of about one in one million.

Now the probable error of an observed angle of average weight in the system, was found to be about one-half a second, which carried through the triangulations, gave results of 65.3 in units of the seventh place of logarithms, as the probable error in the length as computed. Comparing this with the difference actually found between the measured and computed lengths, 1.44 inches, it is seen that the actual discrepancy is about one-third of the probable error derived from uncertainties in the values of the observed angles, and therefore the discrepancy in measurement of the Buffalo Base line is about one in three millions.

WALTER S. RUSSEL.

THE POWER OF WATER MOTORS.

WATER motors are in such common use in cities and towns having water-works, that any information bearing upon their efficiency and power will be of interest to the Society. Perhaps no form of prime mover is so over-rated as the water motor of the Backus and Tuerk types.

A test on a 30-inch Backus motor conducted by the writer last summer in the city of Ann Arbor, will illustrate this point. In the Backus Motor catalogue (see p. 25), the 30-inch Double Motor under a pressure from 75 lbs. to 150 lbs. per square inch, is rated at from 8 to 12 horse-power.

The pressure during the test was about 83 lbs., and the maximum power taken off by the brake was 2.14 H. P., as shown by the following table: —

TEST OF 30-INCH DOUBLE BACKUS MOTOR.

No. of Test.	Radius of brake arm.	Weight of end of arm.	Revolutions per minute.	Brake horse-power.	Remarks.
1.	5¼ ft.	3 lbs.	564	1.692	When radius = 5¼ ft.,
2.	"	4 "	484	1.736	B. H. P. = $\frac{\text{wt.} \times \text{revs.}}{1000}$.
3.	"	5 "	428	2.14	
4.	"	6 "	352	2.112	

The total horse-power and efficiency are as follows: head = $\frac{83}{0.4313}$ = 192 feet; velocity = $\sqrt{64.4} \times 192$ = 113.2 feet per second.

Area of $\frac{1}{2}$-inch nozzle = 0.1963 sq. ins.
" $\frac{7}{16}$ " " = 0.1503 "
Total " nozzles = 0.3466 " = 0.0024 sq. ft.
Volume flowing per second = 113.2 × 0.0024 = 0.2717 cu. ft.
0.2717 × 62.4 = 16.95 lbs. per second.
Coefficient of discharge = 0.8
Actual calculated discharge = 13.560 lbs. per second.
$\frac{192 \times 13.56}{550}$ = 4.73 total horse-power.
Maximum efficiency = $100\frac{2.14}{4.73}$ = 45.2%.

The pipe leading to the motor was large, and put in with easy bends, in all respects a good job. The power realized was without doubt the most to be had with the nozzles used, $\frac{1}{2}$ and $\frac{7}{16}$ inches. The speed of wheel for maximum power was about 428 revolutions per minute = 7.13 per second; and 7.13 × 2.5 × 3.1416 = 55.97 feet, or about one-half the velocity of the jet for the best speed of buckets.

It will be seen, therefore, that the claim of the makers of from 8 to 12 H. P. is scarcely realized; further, it will appear that it cannot be realized when the total power, neglecting the coefficient of discharge, is only $\frac{4.73}{0.8}$ = 5.9 H. P.

Although the Tuerk Motor is also over-rated, it is somewhat nearer the truth than the Backus, as will be shown by the following calculation: A No. 12 Tuerk Motor is about the same size as a 30-inch Backus, and is used with a single $\frac{5}{8}$-inch nozzle. For a pressure of 83 lbs. per square inch (see catalogue, p. 11), this motor should give about 5 horse-power at a speed of about 463 revolutions per minute.

Area of $\frac{5}{8}$ nozzle = 0.3068 square inches = 0.00213 square feet, and 213.2 × 0.00213 = 0.241 cubic feet per second. 0.241 × 62.4 = 15.04 lbs. per second. 0.8 × 15.04 = 12.032 lbs. per second, and $\frac{192 \times 12.032}{550}$ = 4.2 total horse-powers. If there were no losses, then $\frac{4.2}{.8}$ = 5.25 H. P., which is but $\frac{1}{4}$ H. P. above the power rated in the catalogue. The actual H. P. will be not far from 45 per cent × 4.2 = 1.89 H. P.

The efficiency of this class of motors rarely exceeds 50 per cent. The *American Engineer*, issue of April 11, 1885, gives results of experiments on a 30-inch Backus and a No. 11 Tuerk Motor, by Mr. A. J. Jones, Superintendent of the Brunswick (N. J.) water-works, from which the following is extracted:—

Backus.					Tuerk.			
Press.	Rev's.	H. P.	Efficiency.	Wt. of water usd.	Rev's.	H. P.	Efficiency.	Wt. of water usd.
			per cent.	lbs.			per cent.	lbs.
50 lbs.	295	0.394	48.33	232.8	363	.552	46.34	341.2
					305	.696	47.32	468.2
45 "	239	.318	46.	220.2	366	.548	48.02	363.1
					274	.26	49.09	168.7
40 "	287	.273	47.14	207.5	378	.36	46.87	274.9
					364	.554	45.74	433.2
35 "	223	.212	44.7	194.1	312	.302	47.05	258.1
					300	.454	44.85	416.5
30 "	208	.159	42.26	180.	340	.323	43.10	358.2

The power realized from these motors is very small in amount, and the efficiencies are nearly all above 45 per cent. The efficiency of the Backus appears higher with the maximum load for which the whole was tested, while that of the Tuerk is higher for some of the smaller loads.

The amount of water used for any one of these motors doing considerable work, is necessarily large. For example: The Backus double motor tested consumed 13.56 lbs. per second = 48,816 lbs. per hour = 5,858 gallons per hour approximately, or 2,735 gallons per H. P. per hour. For 8 H. P., about 21,880 gallons per hour would be required. It would therefore appear that except for very small powers, the water motor in its present form is not likely to be used to any great extent.

Water motors for considerable power, and known as the Hurdy Gurdy, are used on the Pacific slope in the mining districts under the enormous heads existing there under which turbines would soon wear out. With a special form of bucket, known as the Pelton, an efficiency of over 85 per cent is claimed to have been reached.

M. E. Cooley.

COVERING STEAM PIPES.

The benefits of covering steam pipes to prevent radiation, are strikingly illustrated by the following example: —

The Thompson Houston electric light plant in Ann Arbor has about 60 feet of 7-inch pipe connecting the boilers with the engines, and two large steam drums above the boilers. In March, 1887, the steam at the far end of this pipe was tested to determine the amount of entrained water, the pipes and drums at the time being uncovered. An average of nine experiments gave 31.01 per

cent of moisture. In June of the same year, after the pipes were covered with magnesia sectional coverings, the quality of the steam was again tested, the average of five experiments giving 3.61 per cent moisture. The tests were made by the same men, from the same connections, and in the same manner. The pipes and steam drums in March were subjected to a draught, which of course aided the condensation. Enough water passed into the cylinders to retard the engines, producing a disagreeable noise. In June, the weather was warmer, and the pipes and steam drums were well protected. The quality of steam at the boilers was tested in June, and showed about 3 per cent of moisture.

Assuming that 100 I. H. P. were being developed at the time, and that each horse-power required 30 lbs. steam per hour, we would need 3,000 lbs. steam. If the steam is assumed to have 25 per cent entrained water due to condensation in the pipes and connections, then 4,000 lbs. steam will need to be produced in the boilers, or 1,000 lbs. more than necessary. To produce this steam will require about 125 lbs. of good coal per hour, or 1,000 lbs. per day of 8 hours. One-half ton per day, at $3.00 per ton, for 300 days = $450, which at 6 per cent pays the interest on $7,500. The actual cost of the covering put on complete, probably did not exceed $150.

M. E. COOLEY.

THE MICHIGAN CENTRAL TRANSFER STEAMER "ST. IGNACE."

THE problem of making safe and sure winter connection between ports at different points on our great water-way, has always been difficult of solution. Bridges are not advisable, sometimes not possible, and of necessity transfer steamers and passenger ferries must be used. In comparison with paddle boats, propellers have proved themselves the better workers in ice, if there is plenty of water under them. The Michigan Central R. R Co.'s problem then was, Given plenty of water in the straits of Mackinaw, six miles wide, and plenty deep enough, to construct a transfer that shall be trustworthy in all weathers, and to which ice will be no obstruction. The solution was the "St. Ignace."

She was built in 1888 by the Detroit Dry Dock Co., after designs by Mr. F. E. Kirby, a member of this Society. His experience in planning, and the company's experience in building boats for this kind of work, have made her probably the most successful boat of her class ever built.

She has 201 feet length of keel, 232 feet over all. Extreme breadth, 52 feet; molded depth, 24 feet; capacity, 10 freight cars or 8 passenger cars; light draft, 15 feet; load draft, 17 feet; load

displacement, about 2,600 tons. The lines of her forward and after bodies are very much alike, and are finer than is common with boats of this class, fitting her to attain a speed of about 15 miles per hour. Owing to the rounded shape of her cross section, slush ice, the worst enemy of the flat bottomed boats, cannot stick to her bottom, and so retard her progress. The bottom is completely swept by the powerful currents from the propellers.

The hull is of remarkably strong construction, especially the bow, which has to resist the crushing force of great masses of ice. The frames are 24 inches deep on the keel, and 12 inches thick; spaced, 33 inches centers; planking, 6 inches thick. She is plated from the keel to a point above the water line. All above a point below the load water line, is ½-inch steel. The remainder is $\frac{3}{16}$-inch steel. The stern and rudder guard are specially protected by plating three inches thick. It will be noticed that the lower deck beams, 10 inches square, come just at the level of the load water line, where the pressure of ice is greatest. They are spaced 33 inches centers the entire length of the boat, cut, of course, at the hatches. The drawing also shows the breast hooks, three at each end of the boat. They vary from 11 to 13 inches in thickness. Exceptional care was taken in framing the "dead-wood" at each end, making stem and stern almost as substantial as solid timbering. Between the frames and planking, let into the frames, is a system of diagonals of 5 inches by ⅝ inches iron, bolted to the frames, and riveted together at the crossings, which gives great longitudinal stiffness to the boat.

The two tracks are parallel to the side lines of the deck, leaving room for the cabin between them. The cars are run on at the bow, which is only 20 feet wide, and the tracks cross on the table to simplify the curves on the boat. The swinging table is 50 feet long. The rails are laid on pine sleepers which rest on the upper deck beams, and a line of stanchions runs the length of the boat under the middle of each track, except at the boiler hatch. Here the beams are iron, with channel iron stanchions between the boilers.

The crew are quartered below decks in the after part of the boat. The cabin above decks is very complete in plan, differing in this from the ordinary transfer boats, because of the length of her route.

Kitchen and dining room, ladies' saloon, officers' quarters, smoking room, dressing rooms, etc., are provided and nicely furnished. Additional room is secured on the saloon deck by making it project over the lower cabin at the sides, still leaving plenty of room to work on deck around the cars.

She has two fore-and-aft vertical compound engines, the forward one being 26-inch and 48-inch cylinders by 40-inch stroke; after one 38½-inch and 53-inch cylinders by 48-inch stroke. The forward propeller is 10½ feet in diameter and 15½ feet pitch. It is so con-

structed that all its faces are driving faces, hence it is equally efficient whether its engine is working forward or reversed. The after wheel is 12 feet in diameter, and 15½ feet pitch. Both are well below the water line out of reach of the ice, the top of the forward one being nearly 6 feet, and of the after one 4 feet below the surface when she is loaded. The shafts are each about 70 feet long, including crank shafts.

The boilers are three in number, of steel, 11½ x 18 feet, working at 130 pounds' pressure. They are of the double-ended type, combustion chamber in the middle. There are four furnaces, aggregating 91 square feet of grate surface in each boiler, burning all together about 10,000 pounds of coal per hour. They occupy about 34 feet of length in the middle of the boat. They are connected to a single steam drum, from which the steam is distributed to the engines. The steam pipes are of copper, and exhaust pipes to condenser are of wrought iron.

A single condenser is used, located by the side of the after engine. The two air pumps, 24-inch diameter, and 16-inch stroke, work at the ends of a beam operated by special engines, so that either of the main engines may be stopped at will.

The coal bunkers are of 300 tons' capacity, between the boilers and engines. The coal hatches, 4 in number, are between the rails, so that the coal can be taken from hopper cars without handling.

The steamer is steered by a specially designed steering engine situated on the main deck, 27 feet below the pilot house floor. The valve is operated by a hand wheel in the pilot house. There is also a pair of large steering wheels connected directly with the drum on which the ¾-inch wire tiller ropes are wound, for use in case of accident to the engine. The rudder stock is 9 inches in diameter, and as the rudder is protected from the ice by a heavy wing of timber, there is scarcely any possibility of injury to that part of the apparatus. A 6,000 candle-power electric light, operated by a small dynamo in the after engine room, and capable of being turned in any direction by the pilot, is placed on the pilot house.

A valuable feature of the outfit not possessed certainly by any other boat on the lakes, and probably by no other American-built boat, consists of two iron tanks 6 feet square, extending the breadth of the boat on the main deck. They contain from 15 to 20 tons of water each, and act as anti-rolling tanks. When the boat rolls, the water runs to the lower end of the tank, and is just enough behind the roll to meet the boat as she rises, so that it is always found on the rising side of the boat. This principle, applied by Mr. Kirby to a small model, reduced the rolling more than 75 per cent.

There are four steam capstans on the deck for handling the lines quickly and effectively when the boat is at the dock. The engines are close up against the lower side of the beams, out of the way,

and nothing appears above deck but the capstan head, and the handle for opening the steam valve.

To prevent the heavy waves or the ice from coming over the bow, a heavy gate has been constructed, swinging on hinges set on top of the rail of the boat, which rises up to let the cars pass under.

Under the head of "outfit" might be noticed a portable dock which was sent with the boat. It fits either end of the boat well enough to be made water-tight by a loosely spun rope of oakum. In case of damage to a propeller, this dock can be put on, pumped out, and the damage attended to while she is at her wharf.

As the cars, especially long passenger cars, come very close to the cabin when she is loaded, it was thought advisable to provide against the consequences of a sudden lurch of the boat in heavy weather, by putting screw jacks under the corners of the cars to prevent rocking. They are put under all four corners of each car on a very rough passage, but need not be used much in summer.

By her performance, the "St. Ignace" has realized the hopes of her most sanguine friends. Her anti-rolling tanks have been thoroughly tested by using them with all depths of water in them. Full of water, they only increase the roll, bringing it near the danger limit in very rough weather; but used half full, or a little less, the effect is as great as was anticipated from the use of the model referred to. She rolls very slowly, with no quick recoil appreciable.

She has cut her way through field ice two feet thick without great difficulty or any injury to herself, and has not been hindered by ice clinging to her bottom, as before noted. The severest test of her power is applied when she crosses a "windrow" of ice. These windrows are piled up at the leeward edge of a field during a hard blow, and are sometimes twenty feet deep, and consist of loose ice and slush. She has never been stopped by one of them, and from the way she has behaved at these times, it is thought she will meet all the demands upon her in the future.

To come into her slip when it is full of ice, the after engine is worked full speed ahead, while the forward one is reversed. As the after one is twice as powerful as the other, she works slowly ahead, while the forward engine throws into the slip under the ice a powerful current of water that heaves it up and breaks it. Then with both engines full speed ahead, she forges into the slip, and the ice is further ground up and drawn out by the current under the boat.

With such complete success in view, it may be that some day we shall see a fleet of boats, headed by another of the "St. Ignace" type, making the trip from Chicago to Buffalo as regularly in winter as in summer, without a day's stoppage "icebound."

E. L. Mc ALLASTER.

LAKE SUPERIOR MINES.

To the President and Gentlemen of the Michigan Engineering Society: —

THE country bordering the "great unsalted sea" of the North, is one of marvelous mineral resources. That portion of it known as the upper peninsula of Michigan, is an empire within itself. But the blue waters of the lake wash also the far-reaching shores of Wisconsin, Minnesota, and Canada. The stores of valuable mineral, already discovered in all of those sections, excite the wonder of the most casual observer. Indeed, they attract the attention of the whole world. The products of the mines of Lake Superior have found their way to the most distant markets, and, owing to their excellence and purity, are highly appreciated, and eagerly sought after.

During the season of 1888, the iron mines yielded 4,671,947 tons of ore. During the same period, the copper mines shipped 59,574,066 pounds of refined copper, equal to more than 29,000 tons.

Within the memory of many of my hearers, this country was called a howling wilderness — a land of ice and snow — not likely to attract settlers, or become the home of civilization. In 1840, in the United States Senate, the great Henry Clay ridiculed the idea of a ship canal at Sault Ste. Marie, and said that we might as well undertake to open a way to the moon.

When the General Government gave us the Upper Peninsula as a sop to allay our angry feelings in the little boundary dispute down by the Maumee, our people received the gift with a scoff and a sneer. But there was a divinity that shaped the contour of our great State better than all the engineers and surveyors of that day could have done it. It is a trite saying that "we do not always know what is best for us." Surveyors often run random lines, not knowing where they will come out. The random work of Uncle Sam in giving us the Upper Peninsula, *nolens volens*, has placed our Michigan at the forefront in the way of resources.

It is with this portion of our commonwealth — the Upper Peninsula — that I now have to do. Your honorable Secretary intimated that a chapter on the mines of Lake Superior would be acceptable at this time. I gladly assented to his proposal, but would venture to remind you that the subject is a broad one. In the brief time allowed by your rules, I can scarcely do more than outline the subject. I must needs invoke the aid of a 40-horse power air-compressor engine, such as is used at the mines, to help in condensation. Highly rarefied "wind," as I understand it, is not favored by this Society.

So I must skip over the topography and surface geology of the country, and bring you at once down to the mines. All specula-

tions as to the origin of the chief minerals, their abundance, and as to what future discovery may reveal, must be ignored.

The two principal fields, at the present time, are those of iron and copper. It is to the mines in these fields that I would call your attention. There are silver and gold mines of great promise, but those industries are as yet in their infancy. Other valuable minerals are known to exist, but their development lies in the future.

The iron fields are the most extensive. Actual discovery covers a large territory, but much is left to be revealed. Beginning far down the Menominee River, the iron belts sweep through the counties of Menominee, Iron, Marquette, Baraga, Ontonagon, and Agogebic, hundreds of miles, and, overleaping the western boundary of Michigan, pass into Wisconsin, and over into Minnesota on the north side of the Lake, — a grand sweep indeed. The arithmetic of man would fail in estimating the hidden wealth of this vast territory. The iron ore is of the best quality; there are several varieties. The Bessimer and Magnetic ore are the most valuable. The immense deposits of ore, found in individual mines, is wonderful. The hard facts in the case do away with fable. Bodies of pure ore, thousands of feet in length, a hundred feet in width, and of unknown depth, invite the miner's attention, and reward his toil.

The geological surveys under Dr. Houghton afforded a glimmering of the existence of iron in the Upper Peninsula, but it was reserved for Mr. Philo M. Everett, of Jackson, Mich., who organized the Jackson Mining Co., to discover, under the guidance of an old trapper and fisherman, a Frenchman named Louis Nolan, ridges of ore, at a place back of Carp River (now Marquette), near Teal Lake. Professor Shepard, of New Haven, Conn., when shown a specimen of the ore, declared it to be very fine, but thought it nearly worthless, as it was so far away. Numerous successful and very profitable mines of many years' standing attest the value of this discovery, and the two flourishing cities of Negaunee and Ishpeming bear witness to the richness of the ore beds around Teal Lake. If you wish to see industry, enterprise, skill, and prosperity exemplified, visit these thriving mining and pioneer centers.

At first, the shining black or slate-colored iron ore cropped out in long narrow ridges, from 20 to 100 feet above the general surface. The faces of the cliffs were denuded, often polished. They had *weathered* in many places, and masses of the pure ore had rolled down to the bottom. The first mining operations were simple enough, and consisted in quarrying the ore on the surface. But as the work went on, and mining went under ground, new and more scientific methods had to be adopted. Regular shafts were sunk, and underground drifts or galleries were planned. The aid of machinery was called in. Shaft and engine houses were built;

in short, the original quarry became, in time, a great mine, with all modern appliances in equipment and plant. A busy mining town, homes of the miners, operatives, and merchants, grew up close by. Tram car tracks checker the surface, and the locomotive, hauling long trains of ore cars, is busy in every direction. The earth is torn up on all sides; *here* a pile of waste material; *there* a pile of shining ore in the stock pile; and, in the midst, great yawning excavations, whence the iron has been removed, and which you must take care not to approach heedlessly.

The older mines are now down many hundred feet. Heavy hoisting machinery is used in bringing the ore to the surface. Then T-railways lead down into the mine. Tram roads are laid in the underground galleries. Long steel drills, run by compressed air, bore a 2½-inch hole 20 feet deep, speedily into the solid ore. A dynamite cartridge is dropped into it, and the explosion brings down great masses of a hundred tons or so. This is re-broken, loaded into cars, trammed by men to the skip shafts, hoisted to the surface, and dumped on the platform prepared for it. Here it is assorted, loaded on ten-ton cars, and hauled to the Great Lake or elsewhere. Mining for iron is a simpler matter than mining for copper. Still some of the iron mines are of such great width, and the containing rocks are so unstable, that much timber and engineering skill are called into requisition in placing it. Large pumps are necessary to free the mine of water. The mines are well ventilated, the air pure, with no dangerous gases threatening explosions. Care is exercised in the use of high explosives, only the most intelligent and trusty men being allowed to use them.

Great skill, great economy, a liberal use of modern inventions, are seen at these mines. The progress made in mining during the last quarter of a century exceeds all pre-conceived ideas or practice. It is such inventions and appliances that insure the success of mining to-day.

Most of the mining corporations of Lake Superior show great liberality toward their employees, and some of them show a humane spirit which is truly admirable. Churches, hospitals, schools, libraries, places of innocent amusement, comfortable cottages, etc., are provided for the people. I am happy to say that the squalor, poverty, misery, and turbulence that characterize many mining communities do not exist on Lake Superior; and I am inclined to believe that Lake Superior miners, as a class, are "superior" men.

But I can devote no more space to the iron mines. I already stand in fear of the President's bell, lest it ring me down.

We now come to the copper district, which occupies a distinct geological field north of the iron.

By reference to a map of Lake Superior, you will observe a prominent cape jutting far out into the lake. This is known as Keweenaw Point. By reason of the artificial canal, named the

Portage Lake and Lake Superior Ship Canal, this point is now actually an island. The copper-bearing rocks constitute the backbone of this remarkable cape. The trap range, as this backbone is called, begins at the extreme northeast end of the Point, and runs in a southwesterly direction through Keweenaw, Houghton, and Ontonagon counties, a distance of about 150 miles. The width of the range varies from three to four miles, flanked by sandstone, metamorphic, and old red. It is composed of trappean rocks of different kinds. The whole range is tilted up from 32° to 45°. Originally the beds occupied a horizontal position, and were probably of sedimentary origin. At the advent of the white man, the whole surface was covered with a dense forest, the underbrush being very close. The elevation of the range is from 500 to 1,500 feet above the surface of the lake. Three classes of veins and lodes have been worked, — the true fissure vein, as at the Cliff mine; the contact vein, as at the Minnesota; the amygdaloid belt or lode, as at the Quincy; and the conglomerate lode, as at the Calumet and Hecla. These are characteristic. Fissure veins cross the range at right angles, having a northerly and southerly course, and dipping a few degrees to the east. These veins produce mass copper, as main out-put. The contact vein runs with the formation, and also produces mass copper. The amygdaloid and conglomerate belts or lodes, also run with the formation constituting a part of the solid mass, and while they yield considerable irregular mass copper, their main supply and dependence are found in what is called "stamp copper," that is to say, virgin or native copper in the shape of shot or flakes distributed throughout the matrix of the lode, requiring stamping and washing to fit it for the smelting works. I beg to remark that the Lake Superior copper is not an *ore*, like iron or the sulphuret of copper, but a virgin metal, like gold. Copper ore, it is true, is found at some points on the range, but its exploitation has never, thus far, been attended with success.

The existence of copper in that country was known to the aborigines and to the *voyageurs* and Jesuits. An English company, under Henry, in the last century, undertook mining in that region, but failed. The astute Ben. Franklin was informed on the subject. As one of the commissioners to settle the boundary line between the United States and British Possessions, he carelessly drew a red line through Lake Superior so as to include Isle Royale, which lies within eighteen miles of the Canadian shore, and which, he *guessed* was rich in copper. He was a Yankee, and guessed right.

But long before the Jesuit fathers, with indomitable courage, launched their canoes upon the limpid waters of the lake, an unknown people, named the Ancient Miners, had discovered the copper, and mined for it extensively, though crudely, all through the copper district, including Isle Royale. They were a brave, enterprising people certainly, and their extensive works excite the

wonder and admiration of the modern explorer. They mined with stone hammers and fire.

Dr. Houghton's researches from 1840–45 threw great light on the copper region, and fixed as a certainty the existence of copper in workable veins. The emigration to the new El Dorado rapidly followed his disclosures. Mining was begun, and has continued, under varying circumstances, until the present time. It is now a great and prosperous industry.

Exploring for copper was and is laborious work, owing to the dense forests and deep drift. The drift is anywhere from one to 100 feet deep; at only a few points are the rocks *in situ*, denuded. The discovery of veins and lodes, therefore, is preceded by much digging and trenching, uncertainty and cost.

Modern mining in the copper districts of Lake Superior affords an example of the highest skill, combined with liberal expenditure, indefatigable labor, and profitable results. The road to this high eminence has been long and weary, under losses and discouragements, leaving many wrecks by the way.

Having discovered a lode or vein of promise, we proceed to open a mine. The spot is in the heart of the forest. By ax and brand it must be cleared. Log huts for shelter are erected. Rude engine and shaft houses, carpenter and smith shops, are thrown together with little order. Roads are cut out to the nearest navigable water, in order that supplies and machinery may be brought in. At first the work is tentative. Until the lode has been proved valuable beyond reasonable doubt, expenditures are wisely limited; but the opening of the vein is pushed vigorously. The hunt for copper in quantity is the absorbing business.

But when, after practical experiment — actual work down in the solid crust — the miner feels assured that he has a good mine under his feet, he goes ahead boldly. The engineer lays out the surface ground carefully, locating the working shafts, engine houses, machine shops, rock houses, railways, and town site with care, having in view the future needs of a great mine. The wilderness rapidly disappears, and a bustling mining town, embracing within its limits churches, school-houses, hospitals, stores, miner's cottages, fine mansions, etc., springs up as if by magic. There are hotels without a bar; saloons are *tabooed* on the mine location.

Meantime, the work of sinking shafts, opening drifts, in short, the development of the mine, is pushed day and night. The mining engineer keeps this work well in hand. He establishes a permanent base line on the surface. From this base he carries his triangulations and measurements down the shafts to the underground city. He follows hard after the miner and plats the work on paper at every important step. His fixed points or benches underground are plugs secured in the solid rock. The light of a candle is his guide in the dark recesses of the mine. The working shafts are placed from 400 to 600 feet apart on the line of the lode.

They generally follow the pitch or inclination of the lode in their downward course. At the depth of 100 feet, the first grand level is reached. At this point horizontal drifts are started right and left from the shaft, on the line of the lode. The work in the shaft is ever downward; there is no pause until the second level is reached, and so on to the third and fourth, etc. Between the shafts, below the first level, sub-shafts are sunk to aid in work and ventilation; these are technically called *winzes*. Thus a plan of a well-opened mine resembles a map of a city. The shafts and drifts are the avenues and streets, while the winzes are alleys. The engineer's extended map of the mine, kept in his office, enables him to point out at any time the depth and length of the workings, the position of the pumps, man engine, tram-ways, stopes, rich and poor ground, and the very places where the miners are at work at a certain time.

The mine thus opened, the main work of producing copper begins. The squares in the underground city are mined out from between the walls of the lode. Be the lode five or fifty feet wide, the vein matter, carrying copper, is all blasted down, and hoisted to the surface. This work is called *stoping*. Great chambers are left after the rock is removed. The mine would close up, by the hanging walls' falling down upon the foot, if not prevented by artificial supports, called *stolls*. The heaviest timber to be found in the native forests, — pine and hemlock, — is used for this purpose. They are set up as thick as they can stand all along the drifts. An enormous amount is used monthly. The supply in the yards would cause a stranger to look around for a saw-mill, as a necessary adjunct. Much other timber, called *lagging*, is used under ground to cover the stolls, and for staging. The stolls are so placed that the tram-ways run under them, and the lagging thrown over the stolls prevents the mined rock from impeding the passages, and hurting the men. As the mine is worked out, the upper levels are great unused chasms, but all the timber is left standing. In time this timber becomes very dry. If set on fire, the burning is rapid and fierce, for the shafts are like great chimnies, with excellent draught. The great and disastrous fires which have occurred in the Calumet and Hecla mine within the last two years, afford an example of the danger always threatening a mine of this kind.

Tram roads are laid in each level, and cars pushed by men transport the rock to the hoisting shafts.

The shafts are elaborate and costly. They vary in dimensions, according to the use they are put to. They are solidly timbered and planked from top to bottom, with T-rail tracks laid in them. The track is a steep inclined plane. Cars carrying from four to six tons of rock move up and down with great velocity. These cars, or skips, are made of boiler iron of peculiar shape. Some of the mines are more than 4,000 feet deep. Heavy wire or

steel rope, winding around an immense drum moved by the great engine on the surface, is used in hoisting. The drum is thirty feet in diameter, with friction gear, and one man standing at a little wheel, manages it as easily as a toy. Ingenious indicators, placed before the man, tell him exactly where the car is at any time in the shaft. The skip car is carried thirty or forty feet above the surface of the ground, in the shaft house, where it dumps its load automatically, and immediately descends into the mine.

Surface cars receive the rock, and by means of an endless rope, they are whirled rapidly away to the distant rock house. No man is seen about the shaft house. The cars move automatically, dump themselves, and return to the shaft for another load. Signal bells, under ground and along the surface tram-ways, transmit orders.

The winding engines, moving four thirty-foot drams, are immense in size, but move very quietly, though powerfully.

The pumping-engine is a marvel in its way for power and in construction.

The man engine, used by the miners on their way in and out of the mine, is an ingenious contrivance. It consists of two parallel rods of wood, a foot square, placed about two feet apart in a separate shaft. Every ten feet, on each rod, a narrow platform is placed with an iron hand-railing. In moving, one rod goes down and the other up, with a ten-foot stroke. A miner steps onto one platform, and goes down ten feet. Then he steps across to the opposite platform (which has come up to meet him), and sinks gently down ten feet, and so on, till the bottom of the mine is reached. A hundred men may be on the rods at the same time. All are conveyed rapidly, without fatigue or confusion, to their destinations. There are ladder ways leading down into the mines, but they are not much used. Climbing them is very hard work.

The rock house above alluded to is a great building where the copper rock is dumped, assorted, re-broken, and prepared for the stamp mill. Large blocks of rock, tied together with copper, very tough, are dragged by a chain and steam-power under a great hammer moved also by steam. This hammer or punch is a long solid shaft, standing upright, with a steel pointed end. It drops upon the hard copper rock, and pierces and shatters it like glass.

The broken masses are then conveyed to different sized rock breakers, where they are crunched up into pieces suitable for the stamp mill. From the breakers, the rock falls into great bins; thence it is drawn into rock cars, and drawn by locomotives several miles to the stamps. At the stamp mills this rock is dumped into great bins located near the top of the mill. The rock runs down to the stamp (its motion regulated by one man), where it is crushed to fine sand under a blow of more than forty tons from the steam hammer. A stream of water, pumped up to the top of the building, runs constantly into the stamp mortar, and carries away the sand, slime, and copper to a series of washers moved by machinery.

The jigging movement of the washers causes the copper to settle onto the wire screens, while the water carries the sand and slime away to a place of deposit.

Immense pumping machinery is used. A large volume of water is, in some cases, elevated 100 feet, and distributed. Each stamp has a capacity of crushing from 100 to 150 tons of hard rock, during each twenty-four hours. The Calumet and Hecla mine has sixteen to twenty of these stamps, and can stamp at least 1,600 tons per day.

The limit of my article will not permit me to make more than this brief mention of the great stamp mills in the copper districts.

Most of the mines have fully equipped steam freight railroads of their own, which are kept constantly busy.

Large smelting works for reducing and putting the copper in shape for market, are appendages of the mines. There are likewise rolling mills of great capacity, wherein sheet copper, wire copper, etc., are made and shipped.

The old-fashioned way of mining with hand drills and black powder, is now obsolete. Power drills, run with compressed air, do the boring in the solid, copper-fastened rock. Dynamite cartridges do the rending and tearing very effectually. These improved methods have greatly reduced the cost of mining, and facilitated the work underground. Nay, they have been the salvation of many mines, during eras of low-priced copper. Each drill does the work of ten men, thus saving the cost of that many miners for each. Work is also done much more rapidly. For example, with powder and the hand drill, two levels only could be sunk in a year. With the power drill and dynamite, one level a month, or twelve in a year, can be sunk. The same proportion holds with drifting, stoping, and other kinds of work.

The diamond drill is much used for exploring purposes, either in sinking from the surface into the earth's crust, or in the mine.

The Calumet conglomerate charged with copper, is well defined and unmistakable. It lies inclosed between trappean rocks of entirely different structure and character. For these reasons, the miners have no difficulty in following the lode.

But in amygdaloid belts, the courses of copper are more irregular and uncertain. The lode proper is sometimes lost, or becomes mixed up with the *country*, or containing rocks. The copper has somehow disappeared. The diamond drill now comes in as an efficient agent. Horizontal holes, one inch in diameter, are bored from a selected level, right and left, and the lost lode is found. Perhaps entirely new and unexpected copper deposits are found to reward the explorer. The diamond drill penetrates twenty to thirty feet per day, at light expense. By the old-fashioned way of *cross-cutting*, six miners often spent a month or six weeks in reaching the same result.

Some bold and neat engineering feats have been achieved at the copper mines. At the Tamarack mine, we have a notable example. This company owned two forty-acre tracts of land, situated some 3,300 feet west of the Calumet lode. The Calumet lode was supposed, in its deeper reaches, to dip under this land. But the great problem to be solved was this: If it *does* dip thus far, does it carry copper as rich as that in the Calumet mine? does it carry copper at all? The Tamarack Co. boldly determined to solve the riddle. They sank, in about two years, and at great expense, a huge shaft, large enough for double skip tracks and the pump, over 2,300 feet perpendicularly through the barren trap rock of the country. They struck the Calumet conglomerate about where they expected to, and "*struck it rich.*" It is now the second best copper mine on Lake Superior. The Tamarack mine offers the only example of a perpendicular shaft in the stamp copper mines.

The rapidity with which the shaft was sunk, as compared with old-time mining, was truly marvelous. Boldness, skill, energy, capital, dynamite, and power drills were the important factors in this great work.

I have mentioned incidentally some of the duties of engineers and surveyors at the mines. Every large mine has its engineer and assistants. They are salaried men, and hold honorable, responsible positions. Their duties are various, but not exacting. Many of them are practical chemists and geologists. As civil engineers, they build railroads, and keep them in repair; locate stamp mills, pumping machinery, engine, shaft, and rock houses; and, in short, they look after the *mine plant.* Under ground they have various important duties.

The best hoisting, transit, and drilling instruments are used by them. Great exactness is required. The magnetic needle cannot be depended on in their work. The rocks are so full of iron as to render a common compass untrustworthy. The local variation or deflection is often 20° to 30° in one-half mile. In the woods, the best surveyors have been led astray by the compass, so as to become absolutely lost.

In the iron mines the dip needle has been a useful instrument in the search for hidden lodes or beds. In explorations for copper, this instrument has not been of practical importance.

In engineering, all important work is carried on by triangulation from a base and determined true meridian.

The timbering in mines, where, as the miners say, the ground is "*balky,*" is a matter of first importance. The engineer and timberman are called upon to exercise skill and courage. The hanging wall, after the vein matter has been removed, is a great overhanging cliff. If the ground is seamy or shattered, great masses fall. Good timbering prevents this, but in some fissure veins, the best timbering serves only a temporary purpose. The

dynamic forces at work in the earth's crust, sooner or later close up the openings. The largest timbers are as reeds. The slow, imperceptible, but mighty movements of the rocks, "broom up" the ends of the big stolls, and reduce them to pulp, between the closing jaws of the walls.

In the heart of the mines, at Houghton, a miningl school has been established by the State. A very handsome bu iding of red sandstone, found at Portage Entry, ten miles distant, has been erected on the sightly shores of Portage Lake. Under an able corps of instructors, this institution is doing a grand work. The students are taught higher mathematics, chemistry, mineralogy, geology, and civil, mining, and mechanical engineering. These studies are supplemented by actual work or observation in the field, mine, smelting works, rolling mills, stamping mills, and engine and machine shops. The advantages afforded for practical observation and application are unexampled in this country.

JOHN H. FORSTER.

MANIPULATION OF IRON AND STEEL, AND SIMPLE FORGE-SHOP TESTS.

TESTING of iron and steel in the forge-shop by engineers is of much more importance, and ought to have more attention, than it usually receives. I have talked with quite a number of engineers and architects who said they could not tell good iron from poor iron, and relied almost entirely upon the brand, which is all right in some cases, but will not answer in others. An iron may be very good for one thing, and very poor for another, which makes it necessary to determine whether the iron is fitted for the work in question.

In this brief paper, I will give a few important tests that can be made in the forge-shop. These tests should really accompany those made on the testing machine.

First, it may help us to understand the working of iron if we know its nature, and how it is produced. I must say I consider this important. Only a short time ago I was talking with a gentleman in Detroit, who said he had trouble with working his iron, and could not account for it. I found he had been working it wrong.

Now I will give a hasty outline of the production and nature of iron alloys, for that is what commercial iron is.

Chemically pure iron exists only as a laboratory specimen, and would be of little use on account of its softness and tendency to rust.

Some of the elements improve the quality of the iron, under certain conditions and for certain purposes; as, for instance, carbon in the graphite state makes pig iron, and in the combined state,

makes chilled iron and steel. Other elements, as sulphur and phosphorus, injure iron, and render it poor for almost any purpose. Iron or its alloys is divided into three great classes, and these again subdivided into many more. I will give them in the order in which they have come into use: (1.) Wrought Iron; (2.) Steel; (3.) Cast Iron.

The first two of these have been known and worked from the beginning of history, but the last one is of recent date; and I think we may look for other alloys in practical use before many years.

Wrought iron was produced from very rich ores piled in with great quantities of charcoal in a pot-shaped hole in the ground, and blown by some crude, artificial means. The air was directed on the melted metal somewhat, and the metal was kept stirred with a rod. This decarbonizes it, and leaves a pasty mass instead of a liquid. This mass is called a "bloom," and was drawn out under the hand hammer and thoroughly welded together; this squeezes the slag out of it as well. Charcoal was the only fuel for centuries, and is the best to-day, but cannot be obtained in sufficient quantities to supply the market. About 1600 A. D., pit-coal began to be used, and in 1700, coke. Since then, the iron industry has developed into enormous proportions, aided by the steam-hammer and the steam-engine. Later on the *direct* process of making wrought iron was invented. The product of this furnace is called a bloom, the same as in the primitive furnace, but the blooms are drawn out under the steam hammer, and not by hand. *I wish to call your attention to the blooms as they are taken from the furnace, as this will help us in understanding wrought iron.* The blooms are fibrous and stringy. Perhaps an illustration may make it more clear. If we should take a large number of small rods, bent in all sorts of shapes and tangled together, put them into a furnace, and heat to a welding heat, with a little sand thrown on them, we would have a very good bloom. The fibers or rods lie in every direction; and if we pound the mass into a plate or slab, the fibers lie in one plane. Then the plates are cut, re-heated, welded, and hammered on four sides. This makes shear iron; if the process is repeated, it makes double shear iron. These irons are used in the merchant bar. This kind of iron is tough and fibrous in the direction of its length, if well puddled and welded. But if not well worked, it is apt to be seamy, and crack easily. The shearing and re-shearing up to the sixth time improves the iron. Then it ceases to be of value, and becomes injurious. This process is rarely ever repeated more than twice. In 1856 the Bessemer process of making wrought iron and steel was invented, by which the iron was decarbonized by forcing a large number of small streams of air through it. This freed the iron from carbon and most of the other impurities, and then the iron was cast into ingots. These ingots are very homogeneous and ductile. When cast, they are not fibrous, but seem to be a mass of globules or grains held firmly to-

gether. When the ingot is rolled, these globules seem to elongate, and to resemble fibers to some extent. This kind of iron is stronger and more ductile than bloom iron, and is also free from flaws.

Steel, the next alloy of iron, dates back almost as far as wrought iron, and was made in the same primitive furnace by leaving enough of the carbon in the iron to make it harden and temper. This steel might, under very favorable circumstances, be quite good; but generally it was poor, unreliable, and full of flaws. Mild steel, and even some grades of high steel, are produced in the Bessemer converta by first decarbonizing cast iron, then adding just enough carbon to make the quality of steel required, and then casting into ingots, and rolling into the required shape. This steel is malleable, and can be welded when it contains less than one per cent of carbon. Tool shear-steel is made by heating very fine grades of wrought iron in a furnace with layers of charcoal, and keeping at a red heat for from ten to fifteen days. This is called the cementation process. Crucible steel is made from cemented steel by melting in a crucible, casting into ingots, and drawing out into bars. This steel is very homogeneous, and will harden to a great degree. Crucible steel can be made by melting small pieces of fine iron in a crucible with charcoal. This steel has been made for about 200 years, and has from 81 hundredths of one per cent to one and one-quarter per cent of carbon.

Cast iron is a direct product of the ore when it is melted and drawn off without being decarbonized. Strange as it may seem, it appears to have been put to but little use till within about 300 years. The art of making large castings, and the use of the cupulo furnace, belong to the work of the last 120 years. Cast iron does not properly belong in this paper, and I will drop it here.

Testing of wrought iron and steel in the forge shop, to determine whether the metal in question is good, bad, or fitted to its use, is a very interesting piece of work. Usually the testing machine would do some of this work better, and will of course do work that cannot be done in the shop; but on the other hand, the forge shows things that the testing machine will not.

HEATS.

There are four principal heats, as follows: First, low red or cherry heat, where the iron just turns red; second, red heat; third, white heat; fourth, welding or sparkling heat, where the iron begins to fuse; but as soon as the iron looks greasy, it should be removed from the fire, as the high heat oxidizes the iron, or burns it away.

FLUXES.

The fluxes used in welding are quartz sand for wrought iron and low steel. The silicon unites with the oxide of iron, and

forms the silicate of iron, which is a slag. This forms a greasy coating over the iron, and protects it from further oxidation.

When the iron has reached the welding heat, the two pieces to be welded are brought together and the blow struck, the slag squeezes out, and the bright iron unites. Borax is perhaps a rather better flux. I find a large number of blacksmiths who do not know what they use borax or sand for, but seem to have an idea that it acts as a sort of cement to stick the iron together, whereas if they knew the real use of the flux, they would use less of it on clean iron than on rusty. An excess of flux, and consequently of slag, is objectionable. Borax should be used for most steels containing less than 75 hundredths of one per cent of carbon. It fluxes better, and forms a thinner coating on the iron. The borax should be first heated to expel the water, as it contains a large amount of it. When it is required to weld steel of a high grade, the flux used should be one part of sal ammoniac and sixteen parts of borax. The sal ammoniac cleans the steel a little better, so it is well to use a small amount of it with borax. High grades of steel must be worked at a low white heat, as the carbon at a high heat has an affinity for oxygen, and will leave the steel. High steel will weld at a much lower heat than wrought iron, as the carbon helps to flux the iron at a low temperature.

HARDENING.

Wrought iron will not harden at any heat when plunged in water. But poor wrought iron containing some carbon will harden in spots. Steel with less than 15 hundredths of one per cent of carbon will soften when plunged into water of less than 60° F. But all grades of steel with more than 15 hundredths of one per cent of carbon will harden in water at 60° F. The proper heat for hardening is from cherry red to red. Cast iron will chill when heated and plunged into cold water.

HARDENING FLUIDS.

When it is required to harden steel, we have to use some substance that will remove the heat quickly; the quicker, the harder the steel. Some form of liquid is generally used. For a moderate degree of hardness, used tallow. For a little harder, use lard oil at 60° F.; next, water at 60° F.; next, salt and water very cold; and for very hard, use mercury. This will make the steel hard enough to cut most substances except the diamond. All of the hard steels are very brittle.

TEMPERING.

Tempering is the process of reducing hardness. All ordinary steels when hardened are capable of having the hardness reduced by heat. The heat required to draw the temper is quite low, about

400° to 500° F. Cast iron will harden, as we have seen, but will not temper much. When it is required to temper a piece of hardened steel, the surface is first made bright; then heat is applied; at first a yellowish white or bright straw appears, then a dark straw, golden color, brown, purple, violet, and deep blue. These colors form what is known as the tempering scale. All degrees of hardness come between the two extremes. The details of hardening and tempering would make a long paper. There is one steel on the market which will not temper; that is, Mushitt's, an alloy of tungsten and iron. This steel is very tough. The Damascus steel was probably of this alloy, quite easily made and of good quality; but some are inclined to think that this steel owes as much to poetry and literature for its reputation as to its actual merits.

ANNEALING.

When steel has been hardened, it can be softened again by heating to cherry red, and allowing to cool very slowly, the slower, the softer the steel. This is the reverse of hardening. Chilled cast iron or hard wrought iron can be softened in this way.

MALLEABLE QUALITIES.

Good wrought iron or steel when heated to a cherry red heat can be drawn out to a point without cracking, or can be flattened as thin as tin plate without showing flaws. Cast iron has no malleable qualities, but malleable cast iron can be worked to quite an extent. Good wrought iron can be worked up to the welding heat without injury, but steel of a low grade should not be worked above white heat, and steel of a high grade, at a red heat. Poor wrought iron and poor steel when heated to a red heat and drawn to a point, will crack. It will not stand working into any shape to any extent.

Iron or mild steel may be considered fairly good for forge work, if it will extend one and one-half to two times its original width at cherry heat without cracking. But high grade steel and tool steel will not stand working at a high heat. The high steel should show no signs of cracking at cherry heat, when drawn out to any extent. Poor wrought iron will draw into most shapes at the white heat, unless it is hot-short.

SHORTNESS.

Iron is cold-short if it is brittle when cold. This kind of iron is very poor for any purpose. Red-short iron is brittle at the red heat. Hot-short iron is brittle at the white heat. This last kind of iron may be quite stiff and tough when cold, and is a good iron for some places. Steels are all more or less hot-short.

TO TEST THE QUALITY OF TOOL STEEL.

Take a piece of tool steel, heat to a red heat, draw into a cold chisel of about 30°, grind to an edge of 60°, harden at a cherry-red heat in lard oil at 60° F. Draw the temper down to a purple color. This chisel, when finished, should cut bar iron and annealed steel, cold, without cracking or chipping, if the steel is good. Low steel or wrought iron will not do this. A very good way of finding out at what heat a piece of steel will harden is to take a bar one-half by three-fourths of an inch, and make nicks an inch apart for about eight inches, and place in the fire so the first piece will get white hot and the last barely red. As soon as it is heated, plunge in water at 60° F., then break the bar up at the notches. No. 1 will be very hard and brittle, while No. 8 will be soft. This is Miller and Metcalf's way of testing and examining the fracture. And right here I want to say that Crescent steel, made by Miller & Metcalf, of Pittsburg, is the best I ever used. But ordinarily, mechanics will get a better idea if they should take each one of the pieces, and grind the end to the shape of a lathe tool, and try the cutting qualities in the lathe. The piece that cuts the best for the longest time, will show what temper to use. The pieces could be tested by grinding into cold chisels just as well.

WELDING QUALITIES.

Good wrought iron, and most of the poorer qualities, except iron containing copper, sulphur, and phosphorus, will weld at the welding heat by the use of fluxes. They will look greasy at the high heat. The more fibrous the iron, the better it welds. To test the weld, bend the bar at any place around round iron until it breaks, then bend the weld over the same bar through an equal distance. If this weld holds, it is very good.

Steel, unless very low, will not weld at the high heat on account of cracking. Steel containing more than one and one-fourth per cent of carbon will hardly weld. It, however, can be welded at the white heat with care by using the proper fluxes. It will not do to heat the steel to the welding heat, as the carbon at this heat has too much affinity for oxygen, and will leave the steel. The carbon, however, helps to flux the steel at a lower heat.

Wrought iron which does not weld well is unfit for forge work. But some of the poorer grades may be very good, if they are not to be welded, where stiff iron is required.

UPSETTING.

Good wrought iron and steel should stand upsetting, at a red heat, to one-third of its original length, without cracking. The test pieces should be short. Poor wrought iron will not do this, except at the high heat, and some of it not then. Iron would not

be considered very poor if it would upset to two-thirds of its original length.

Mild steel, if good, will upset to almost any extent. But tool steel should never be upset where it has to stand shocks. It will, however, stand upsetting a large amount without cracking.

HOT BENDING.

Good wrought iron should bend at the white heat around a sharp corner double without cracking. A fairly good iron should bend around its own diameter. Poor iron will not do this. Steel of all grades should bend around a square corner double.

These tests are in the direction of the fibers. Good iron and steel should bend about as much across the fiber as lengthwise. Poorer iron, if fairly good, should bend about one-quarter as much across the grain.

COLD TESTS.— MALLEABLE QUALITIES.

Very good soft wrought iron and very low steel should stand drawing out about one-tenth of its original length without cracking. Ordinary iron will not stand drawing cold. If an iron cracks and breaks easily when cold, it should not be used.

BENDING.

Very good soft iron up to one inch in diameter and one inch thick, should stand bending double without cracking. No iron should be used for intricate forging which will not bend on these diameters up to two inches in diameter.

Construction iron, according to Thurston, should bend cold, as shown by the following table : —

Inches.	Bar Iron.		Bolt Iron.		Cast Iron.	
	Longest inclined.	Transverse.	Longest inclined.	Transverse.	Longest inclined.	Transverse.
.24						
.24 to .28	50″	30″	80″	50″	110″	90″
.32 " .36	45	25	70	40	100	80
.40 " .44	40	20	60	35	90	70
.48 " .52	35	15	50	30	80	60
.56 " .60	30	12	40	25	75	50
.64 " .68	25	10	35	20	70	40
.72 " .76	20	8	30	15	65	35
.80 " .84	15	5	25	10	60	30

Good iron should stand bending across the grain about half as many degrees as with the grain ; fairly good, one-third as many

degrees. Very poor iron will stand bending but very little across the grain.

When a bar three-fourths of an inch in diameter, with a thread cut on it, is bent cold, it should show a crack of less than one-eighth of an inch.

When the machinest cuts the thread on a bar and it crumbles off and shows a large number of small seams, it should not be used without testing in the forge shop.

FRACTURE.

A bar of very good iron, when broken, will show a tough, fibrous structure, free from flaws, and of a dark leaden color. It should show no crystals. Poorer iron may show some seams and little spots of crystals, but the fibers should be tough and of a leaden color. Iron for bridge work should be as free from crystals as possible, and should not be strained beyond a certain limit, as the constant strain and jar tend to crystallization. The oftener the jar, the less the strain should be. Low steel, when broken, should show some fiber and a close grain with a bright luster. Tool steel should have a very fine grain, and a higher luster.

COLD HAMMERING.

This should be avoided, as the best iron, when hammered cold too much, will become crystallized and brittle.

C. G. TAYLOR.

PRACTICAL NOTES ON RAILWAY LOCATION AND CONSTRUCTION.

IN attempting to comply with the request of our worthy Secretary to contribute a paper to be read at this meeting, it has occurred to the writer that a brief account of the work upon which he himself has been engaged for the past two years, together with such comments as his experience may from time to time have suggested, might possibly be of some interest to at least the younger members of the Society. He does not expect to present a single idea that can be called original, nor does he claim that the methods which he adopted were in all cases the best. He only proposes to offer for your consideration an example of engineering construction which has been proved by actual use to be safe, ecomomical, and successful, the most important qualifications to be sought for in all engineering works.

The Chicago, St. Louis & Paducah Railway, of the location and construction of which the writer had charge as Chief Engineer,

extends from Marion, Illinois, to Brooklyn, a small village on the north bank of the Ohio River about three miles below Paducah, Kentucky. It was intended as an extension of what is known as the Cairo Short Line System, and this circumstance limited in some degree the choice of plans for structures to such as would conform as nearly as practicable to the standards which were in use on the old road.

The entire length of the road is fifty-three miles, of which the first ten on the north end are over a rolling country presenting no special difficulties either in location or construction. The next section of five miles crosses the divide between Saline and Sugar creeks, and includes several heavy cuts and some rock-work. Then comes the most rugged and difficult section of Illinois, the crossing of the Ozark Range, a high, rocky ridge, which extends entirely across the State, and therefore could not be turned.

Its summit has a very uniform elevation of about 440 feet above low water in the Ohio River, and presents but few passes favorable for a railroad line. It is composed almost entirely of sand rock of every variety of hardness, and its slopes, deeply cleft by long, rugged, and precipitous ravines, and clothed with dense forests, which often confined the view to the limits of a few rods, fall off so abruptly in both directions, especially to the south, as to present very great difficulties in the way of the economical construction of the road.

From the southern foot of this range the line runs for several miles in a valley shut in on both sides by lofty spurs which shoot out from the main range. It then passes a divide into the immediate valley of the Ohio River, which presents no serious obstacle except the deep gorges cut by the tributary streams, and calling for some of the most expensive structures on the road.

Most of the difficulties of location were met with on about six miles of the Ozark Division, owing to the abrupt descent of the streams, which was more than 200 feet in a mile, and the rugged character of the slopes, which made a surface line entirely impracticable. The best general route was determined by means of preliminary lines run through every gap which appeared at all practicable, but the limits of this paper will not permit any account of the methods employed.

After this had been accomplished, the first important point to be determined was the gradient to be adopted. On the other divisions of the road a maximum gradient of one per cent had been found practicable, and our preliminary surveys showed that by developing the line to a length of about eleven and one-half miles by means of long loops and horseshoe curves, this same gradient could be carried over the ridge. This, however, would have involved an expense which the financial condition of the company would not warrant, and it was determined to build the road on a temporary line, which would answer perhaps for years, until its

business should develop to such an extent as to require something better. For this temporary line the gradient adopted was 1¾ per cent, or 99 feet per mile, and for the following reason: —

Supposing an engine to be pulling its maximum load for a one per cent grade, as would ordinarily be the case with a freight locomotive, it would be obliged, on arriving at the foot of the ridge, either to divide its load and make two or more trips to the top, or employ one or more pusher engines to help it up. It was not desirable, nor did the character of the country require, that *more than one* pusher should be employed, and the choice was therefore confined to a gradient up which two engines could take all, or one engine one-half, of the maximum load. According to the "Tables of Maximum Loads for Locomotives," given in "Wellington's Economical Theory of Railway Location," which are the most convenient and reliable that we have, this would call for a gradient of 2.06 to 2.16 in 100, according to the style of engine used, and, as a general rule, nothing would be gained in economy of operation by adopting any flatter gradient than this, as this would not affect the maximum load on other portions of the road. It was found, however, that a gradient of 1.875 in 100 could be fitted to the ground without any additional cost for construction, and it was therefore adopted for the sake of the small saving in resistance in bad weather.

This maximum gradient was used only on tangents. On the curves, which constituted more than fifty per cent of the Ozark Division, it was reduced at the rate of 0.05 for each degree of curvature. Thus on a 7° curve, the gradient would be $1.875 - (0.05 \times 7) = 1.525$ in 100. From the slight opportunities for observation which the writer has had since the completion of the road, he is inclined to think that possibly this reduction is slightly more than is necessary, and that on a curve compensated to this extent, a train will run a little more easily than on the corresponding tangent. The error, however, if any, was on the safe side.

I mention this matter for the purpose of calling the attention of my younger brethren of the profession to the fact that this practice of reducing gradients to compensate for curvature, though of comparatively recent origin, is now being very generally adopted among the best engineers, and that if they desire to keep up with the procession, they must follow the example.

The rugged character of the Ozark Division required a large amount of sharp curvature, 10° being the sharpest admitted, while 6°, 7°, and 8° curves were numerous. These curves were all flattened at their extremities, the method pursued being that given by Trautwine in his work on "Curves." This method is not very scientific, but practically it answers a very good purpose, and was adopted partly on account of its simplicity, but especially for the reason that it need not be applied until the cross-section stakes are to be set, and the locating engineer, who

has enough head work to do as it is, can make his calculations, and run his lines without taking any account whatever of the flattening of the curves.

While on the subject of field calculations, it may not be amiss to call the attention of the younger members of the Society to a formula which the writer has found of very great value in his field work, and which might be of equal value to them. He learned it from Prof. W. M. Gillespie of Union College, more than thirty years ago, but has never seen it in any published field book, and has reason to believe that few engineers are familiar with it, or at least with the numerous uses that can be made of it. It expresses the divergence of a curve from its tangent, and takes the form —

$$x = \tfrac{1}{8}\, n^2\, D,$$

in which X is the offset or distance of one end of a curve from a tangent passing through the other end, D is the degree of curvature, and N the length of the curve in chords of 100 feet each. Thus a 6° curve will have diverged from its tangent at the end of 500 feet, $\frac{1}{8} \times 5^2 \times 6 = 131\frac{1}{4}$ feet. By making D equal the difference of the degree of curvature of two curves of different radii but having a common origin, X will be their divergence from each other at the end of N stations. This formula is not mathematically exact, and therefore gives only approximate results; but it is sufficiently correct practically for all ordinary cases. It is easily remembered; it requires no tables; and with its aid, with such modifications as a little ingenuity will suggest, and a table of actual tangents for a 1° curve, the locating engineer can solve almost any case that will ordinarily arise in the field. For example: Suppose a 5° curve to the right 8 stations long has been located, and its extremity falls 28 feet too far to the right to throw the tangent on the best ground. Making $x = 28$, we obtain $d = \frac{1}{2}$, showing that a 4° 30′ curve starting from the same origin would pass through the required spot. Again: Suppose that in this same case the new curve is to commence 200 feet back of the first one; then the required divergence from the tangent will be $\frac{1}{8} \times 8^2 \times 5 - 28 = 252$. Substituting this value for x, and making $n = 5 \times 2$, we have $d = 2.88 = 2°\ 53'$.

This formula will also solve several problems in track laying. For instance, making x = gauge of track, and d = the degree of curvature of a turnout track, or corresponding to a given number of frog, n will be the lead of the main frog. With $x = \frac{1}{2}$ gauge, n = lead of crotch frog, and with x = throw of a stub switch, n will be the free length of the switch rail. Other instances might be given of the uses of this formula, but we will now return to our subject.

All changes of grade exceeding 0.5 in 100 feet were rounded off by vertical curves calculated by the formula for a parabola. At summits these curves were usually made 600 feet long, but when

they occurred at the foot of grades, where the effect of the change is much more severe and dangerous through its liability to cause the train to leave the track or break in two, they were made from 800 to 1,200 feet long, according to the magnitude of the change. This is another point in construction which has not until comparatively recent times, received as much attention as should have been given it.

Our embankments were usually made 14 feet wide on the top at sub-grade, with side slopes of 1½ to 1, and the excavations 20 feet wide on the bottom, with slopes of 1 to 1 in earth, and ¼ to 1 in rock. These proportions are in very common use in this country, but, where the finances of a company will warrant an increase of one or two feet in these widths, it would undoubtedly be very desirable, especially on embankments more than ten feet high.

For all small water-courses, the double-strength culvert pipe of vitrified clay, made at St. Louis, Mo., was used. These are thicker and much stronger than the ordinary sewer pipe, the thickness being not less than one-twelfth of the diameter. Only pipes of twelve or fifteen inches diameter were used, and where one line was not thought sufficient to pass the water, two and sometimes three lines were laid. The pipe cost, delivered on the cars at East St. Louis, eighteen and twenty-four and three-fourth cents per lineal foot, and the handling and laying cost thirty-nine and forty-five cents per foot.

There are eleven Howe Truss Bridges, each a single span, one 94 feet, and the other 66 feet long between centers of end blocks. The chords and braces of these bridges were of yellow pine, the finances of the company not warranting the use of iron. The 94-foot span cost $2,650, and the others $1,550 and $1,700 each, for the superstructure alone. Pile abutments were used for all of these bridges except one, where, on account of rocky bottom, framed bents were employed. This course was adopted because, although the road ran for so many miles through a rocky country, and many thousand cubic yards of rock had to be removed, but very little could be found that was suitable for bridge masonry. For the same reason, there were but four stone culverts on the line, all of which were fine specimens of arches of four feet span under high embankments.

The Cairo, Vincennes & Chicago Railway is crossed overhead by a riveted iron girder bridge, 44 feet in length, resting on iron bents supported by stone piers. This bridge, on account of its unusually sharp skew of about 23° is quite an interesting structure.

It may not be out of place here to remark, in passing, that the writer's experience with this crossing has served to strengthen the conviction which had long been growing upon him that the time is fast approaching, if it has not already come, when all crossings of railroads at grade should be absolutely prohibited. Even with

the present great cost of an overhead crossing, it is a question whether it is not more than balanced by the diminished cost and danger of operation, and the rapidly growing use of automatic couplers, by doing away with the necessity of brakemen standing on the roofs of freight cars. This method of diminishing by about six feet the necessary clearance, and thereby reducing the cost of an overhead crossing more than fifty per cent, promises to hasten the day when a grade crossing will be a thing of the past.

With the above exceptions, all openings are crossed by pile or framed trestles, the former being used exclusively except on the Ozark Division, where in five cases the occurrence of rock bottom compelled the use of framed bents. These five cases included all the highest trestles on the road, one of them being 60 feet in hight. When these framed bents exceeded 20 feet in hight, they were built in two or more stories, the upper stories being of a uniform hight of 16 feet, leaving that of the lowest story to come what it might. The individual bents are stiffened by sway bracing of the usual form, and are tied together at each story by four or more horizontal ties, 8 x 8 inches, notched and bolted to the caps and posts. No inclined braces were found necessary, even for the highest trestles, though they would no doubt have added to the strength and security of the structures.

The caps of framed bents are secured to the posts by the usual mortice and tenon joint; those of pile bents are secured to the tops of the piles by drift bolts. The latter method of construction, though superior to the former, both in cost and durability, is not entirely satisfactory, on account of the difficulty of removing the caps when decayed. For this reason it is probable that both methods will eventually be superseded by the system of split caps, which consists of two pieces, 6 x 12 inches, placed from 4 to 8 inches apart, resting on shoulders cut on the sides of the piles or posts, and secured by bolts passing through both pieces and the post. Although this system brings back the shoulders, which are objectionable as affording a lodgment for water, the ease with which the caps can be removed for repairs, without interfering with traffic, will eventually overcome all objections.

The spans of the trestles were 15 feet between centers of bents, and the stringers extended over only a single span. This is not the best nor the strongest construction, but the difficulty and cost of obtaining long sticks in a territory which had been largely stripped of suitable timber, compelled its adoption as a general rule. The stringer under each rail consists of two pieces, 8 x 16 inches, packed 3 inches apart with a wooden packing block 18 inches deep and 4 feet long. The packing blocks are notched 2 inches over the caps, and thus serve very efficiently to keep the bents at their proper distance apart, and prevent any longitudinal movement of the stringers. But notwithstanding this advantage, this construction is objectionable on account of the large surface

which it offers for the lodgment of water. It would be better to insert iron spools or washers between the packing blocks and the stringers. Some engineers use the spools without the packing blocks, but in this case the longitudinal movement of the stringers must be prevented either by the use of iron clamps, or by drift-bolting the stringers to the caps, a very objectionable method, on account of the difficulty of replacing the stringers when decayed. In the case of a transfer incline, however, this construction may be unavoidable, as will be hereafter noted.

Any lateral movement of the stringers is prevented by spreading blocks 3 x 10 inches, spiked to the tops of the caps.

The ties are 6 x 8 inches, and 9 feet long, dopped one inch over the stringers, and spaced 15 inches between centers. There are guard rails, 6 x 7 inches, dopped one inch over the ties, and bolted to every third or fourth tie. These serve the purpose of keeping the ties from bunching, and preventing a derailed train from leaving the structure.

There are no side or jack stringers. These attachments are recommended by many of our best engineers, and are certainly very useful to the unfortunate pedestrian who finds himself confronted by a train on the trestle, where he ought not to be at such a time; but they add much to the cost and very little to the strength of the structure, and it is at least an open question whether they should ever be used.

The use of wooden trestles for crossing water courses seems to be in many cases unavoidable, especially by new companies struggling along with scanty means. They undoubtedly effect a large saving in the first cost of a road, but even when built in the best manner, they are open to very serious objections. The liability to accidental or malicious destruction by fire, and the necessity of constant watchfulness to guard against the insidious effects of decay, make them objects of suspicion, to be avoided whenever it is possible. The $180,000 which the Toledo, Peoria & Western Company paid for personal damages alone, arising from the disaster at Chatsworth in 1887, which was the result of the accidental burning of a small trestle, would have gone far toward equipping the whole road with first-class stone culverts; and who can foresee when or where such an accident may occur again? Where stone for a culvert and earth for an embankment can be obtained at any reasonable cost, a wooden trestle should not be permitted; and where stone cannot be obtained, a wooden box culvert may often be employed with great advantage. Twenty years ago such a structure would have been considered very bad practice, but recent experience on some of the greatest railroad systems in this country has demonstrated that it is safer and more durable than a trestle, and can be renewed without great difficulty, especially with iron pipes.

The most important trestle on the road is one which was built for the purpose of a transfer incline at the southern terminus of the line. As many of the members of this Society may never have had an opportunity to examine a structure of this kind, a brief description of this one may not be without some interest.

The object of an incline is to furnish a means of transferring a car or train from a railroad track onto the deck of a boat, and the reverse, thus answering the purpose of a bridge in transferring it across a stream. It consists usually of a trestle or rock embankment running down into the water of the stream to such a depth that at low water a boat can lie over it. If there is any current in the stream, the incline must of course point *down stream* as nearly in the direction of the current as practicable, as otherwise it would be difficult or impossible for the boat to use it. On this track rests a *cradle*, which is a kind of car whose longitudinal section is triangular in form, the lower sills being parallel to the incline, and the upper ones horizontal, or nearly so. This cradle is pushed down or pulled up to the incline by the locomotive until the track which is laid upon it is at the proper elevation above the water. The outer end of the upper chord of the cradle projects several feet beyond the main structure, and is attached to it only at the inner end, where there is a hinge joint, around which it has a free but limited vertical movement. The outer end is built in the form of a triangular recess faced with iron, into which a corresponding projection on the boat fits closely. An inclined apron projects from the brow of the boat, which, as it approaches the cradle, catches under the free end of the projecting chord, and lifts it up to its place. The boat and cradle are then secured together by turnbuckle screw bolts working in lugs attached to the sides of the two tracks. A car or train can now be pushed down the incline onto the cradle, and thence onto the boat, which conveys it to the other side of the stream, where it is drawn off onto a similar cradle and incline. This method of transferring cars is used very extensively on the Ohio and Mississippi rivers.

The boat may be built with either one or two tracks, but the latter is the more common construction. The incline also may be either single or double tracked, the latter being much the better where a double track boat is used; but when, for the sake of economy, only a single track is built, it must be located so as to fit the outer track of the boat, as otherwise this track could not be used at all.

The boat is usually made long enough to hold from six to eight freight cars on each track.

To enable the boat to land at the cradle, a row of clusters of guide piles is driven on the shore side of the incline. These clusters are driven from 25 to 50 feet apart, and should extend from a point opposite the lower end of the cradle, when it stands on a level with the top of the incline, to a point from 100 to 200

feet below the lower end of the incline, according to the length of the boat. Each cluster contains from three to five piles, driven about four or six feet apart, and drawn together at the top, and confined by strong chains, so as to make them act, as far as possible, like a single pile. These clusters should be driven with their outer faces at a distance from the center line of a double track incline equal to half the beam of the boat, unless, as is frequently the case, a landing barge is interposed between the boat and the guide piles, in order to distribute the shock of the boat over several clusters, in which case this distance must be increased by the width of the barge. In case of a single-track incline and a double-track boat, this distance must be increased by half the distance between the centers of the tracks on the boat. This last distance is commonly 12 feet, but in the "Geo. W. Parker," the boat used at Paducah, it is 14 feet 8½ inches.

The piles in these clusters are usually driven until their tops are from 15 to 20 feet above the track of the incline immediately opposite them, so that at high water many of them are entirely submerged. It is better, however, to have one or two of the piles on the boat side of each cluster project 8 or 10 feet above the others, so as to prevent the boat from dragging her guards over the tops of the clusters, to her possible serious injury. For a similar reason, notches should be cut on the boat side of the cluster piles into which the chains which confine them can be sunk, so as to prevent them from tearing the sides of the boat.

The extreme rise of the Ohio River at Brooklyn, from low water mark to high water, in 1884, was about 53 feet, and as it was determined to make the upper end of the incline one foot above high water, and the lower end 6 feet below low water, a total fall of 60 feet had to be provided for. As actually constructed, the incline will be, when completed, 1,538 feet in length, of which 1,290 feet have a fall of 3.4 feet in 100, and 248 feet at the lower end, which will be used only in low water, and will then be occupied almost entirely by the cradle, which has a fall of 6 feet or more in 100. An additional length of 420 feet of trestle connects the head of the incline with the brow of the bluff, on which the Brooklyn yards are located.

The entire incline is built upon pile, even through a cut several feet deep, which it was necessary to make.

A structure of this kind is subjected to very severe strains from drift wood and ice, which sometimes pile up in enormous masses, and more than ordinary care must be taken to prepare it to resist these strains. For this reason, the plans in use elsewhere on the road were somewhat modified. The stringers were made long enough to cover two spans, and laid so as to break joints. Each stringer was secured to the caps by drift bolts; each tie was drifted to the stringers, and a stick of timber 6 x 6 inches was drifted to the outer ends of the ties to prevent ice or drift from catching

on them. The guard rails were omitted on account of their interfering with the movement of the cradle. In this particular, the writer felt constrained by the necessity of conforming to standards; but if he were building another incline, with entire freedom to carry out his own ideas, he would make the ties at least 11 feet long, and retain the guard rails for their use in binding the whole structure more firmly together.

The construction was carried on in the usual manner until the surface of the water was reached, 263 feet from the lower end of the incline, when a sudden rise of the river drove the workmen away, leaving them barely time to lay the steel rails on the lower end of the finished work.

As there was soon depth of water at this point sufficient to operate the boat, the further extension of the incline was suspended. A day was set for opening the road, and the work above water was completed, when a fall in the river, as sudden and rapid as the rise had been, compelled the speedy resumption of work on the lower end. We had but little over four days to prepare for passing over the first passenger train, and it was very important that the expectations of the management should not be disappointed. The piles for the river work were driven by a pile-driver on a barge. The cutting was at first done by a diver working with a hand-saw, under water, but this method proving very slow and unsatisfactory, a cross-cut saw was attached to a light triangular wooden frame, the apex of which was hung to the pile at such a hight that the saw rested against the pile at the proper hight for the cut-off. This was regulated by a vertical gauge on the bottom of which was a step for the saw to rest on. The sawing was then done by three men standing on a raft, one of whom kept the frame pressed against the pile, while the other two drew the saw forward and backward by means of long cords attached to its handles. With this crude and simple contrivance, the head of a pile was frequently taken off in fifteen minutes. A small rod with a sharp point was then driven into the center of one of the piles, and projected above the water. A drift-bolt hole was bored through the cap, which was then dropped over the rod and weighted down with chains. The diver swung it into its proper place over the piles, and guided the point of the long auger, with which a man on the raft bored the drift bolt holes over the center of each pile. Another small rod was inserted in each of these holes in succession, and over it a section of gas pipe was dropped down onto the cap. The rod was then withdrawn, and a drift bolt dropped down the pipe into the hole, and driven home with a heavy, flat-ended bar working in the gas pipe.

Now came what in some respects was the most difficult part of the work, the erection of the superstructure. In the case of an incline at East Carondelet, Ill., whose construction the writer superintended in 1882, the entire under-water part of the superstruct-

ure was framed in one section on rollers on the top of the out-of-water track, and then drawn down into its place by a tug. This operation required considerable time, and was therefore impracticable in the present case. The track was therefore framed in sections 60 feet in length, covering 4 spans. The first section was framed in the usual way, except that in the upper span the chord pieces were so placed as to inclose the stringers above and below. The joints were so framed as to come as nearly as practicable over the centers of the caps, but the care required to accomplish this, on account of the unavoidable irregularities in the driving of the bents under water, and the weakness which would be the result if the joints were not brought directly over the caps, led to the adoption of a different plan for the remaining sections. The spans were reduced to 13 feet, and the stringers framed in pairs without breaking joints, each pair being alternately inside and outside of the adjoining pairs above and below. The stringers being 30 feet long, each pair extended over two spans, and lapped 18 inches beyond the caps at each end, thus securing a firm bearing, independent of the adjoining pairs, even if there were a variation of a foot or two in the length of the spans. The holes for the packing bolts, which connected the adjacent pairs, were bored about half an inch larger than the bolts, so as to give the stringers a moderate hinge motion, by which they could adjust themselves to any slight irregularities in the hights of the caps, and thus secure a firm bearing.

Work under water can seldom be done with the same precision as on land, and some provision must therefore be made for unavoidable inaccuracies. The stringers were put together on the top of the finished track, the ties dopped and drifted onto the stringers, and the rails laid, and the section was then drawn into the water by the transfer boat, which supported the outer end, while the inner end was suspended from the cradle, and drawn back into its place by men standing on the incline. This last operation sometimes occupied several hours, on account of the difficulties which attend all under-water operations; and on one occasion the diver had his leg broken by being caught between the ends of the fixed and loose rails as they were slipping together. When the ends were once brought together, the fish plates were bolted on by the diver; the section was then weighted down onto each cap in succession, by pushing down the cradle; the stringers were drifted onto the caps; and the work was done.

This paper has extended to such an unconscionable length that the writer omits any description of the cradle which was used on this incline. He has, however, brought with him the plans of this, as well as several of the other structures on the road, for the amusement of any members of the Society who may choose to examine them. It was his intention to have copies made of all of these plans, as well as photographs of some of the structures and of

the natural features of the road, to present to this Society; but the want of time has prevented him from carrying out this intention. He hopes to do so, however, at some future time, and mentions the subject now simply for the purpose of suggesting that the exhibition and presentation of such plans might be made productive of much good to the members of this Society. If each member would at each meeting present the working plans of even *one* structure which he had actually built, we should soon have a set of plans in all branches of engineering, ranging from a board fence to a cantalever bridge, from which we might all get some useful ideas.

Engineering is very largely an empirical science, embodying the best results of the successes and failures of generations of experimenters; and he who expects to plan all the structures which he may be called upon to erect, without any regard to what others before him have done, will soon find that he has attempted to shoulder too heavy a burden. There is not one of us who is not liable to be called upon at any time to plan some structure with which he is not perfectly familiar; and if he could feel assured that in the rooms of this Society he could find valuable hints, if not just what he wants, in the experience there recorded, the Society rooms might in time become a Mecca toward which all our footsteps would gladly turn.

EMERY W. MUENSCHER, C. E.

RAILWAY LOCATION IN THE HILLS AND FORESTS OF MICHIGAN.

LOCATING a railroad line through the forests and among the hills of Michigan in a locality unknown to the engineer, is much like finding an unobstructed path through a dark garret, into which has been piled promiscuous heaps of boxes, barrels, furniture, and everything hard to climb over. While engaged in either occupation, you will be apt to run into something as disagreeable as it is surprising. This unexpected contact will breed thoughts that will hardly be orthodox, and if they are uttered at all, they would better be murmured in a low voice, while you are thus alone in the woods or in the dark.

Before much progress can be made in finding a good location, the country through which the line is to run must be thoroughly known.

The initial and objective points, and probably some places between them, have been decided upon by the business managers of a road, and the question of how to connect these points with a railroad running in the most direct line, with grades as nearly level as possible, and with the least expenditure of money, is referred to the engineering department.

All possible information relative to the topography of the district between these points, is gathered from maps and from people who are acquainted with the whole or a part of the country. The latter, however, should be taken with caution, as will be shown later.

The published maps of the northwestern part of the Lower Peninsula, which we have been able to secure, have been found to be unreliable in marking the location of streams, and in topographical data generally. But information gathered from people and maps cannot take the place of going over the country and becoming acquainted with it personally.

The really valuable information must be gathered from the field by the engineer himself, and placed upon a map of his own construction.

In places where no clearings have been made, the forests are so dense that only a few acres can be seen from a given point, and but little can be learned of the nature of the ground without a systematic examination of the whole region through which it is required to locate a railroad. I have been able to find no rule by which a feasible route can be marked on a map, before walking *over*, *around*, and *through* the hills and in the valleys, unless the information can be obtained from some one like our worthy President, who can mark the exact location upon a map for you. This cannot be called an exception to this lack of a rule, for his acquaintance with the Grand Traverse region was gained by the sweat of his brow.

In the northwestern part of the Lower Peninsula, where the writer is most familiar with the hills, there appears to be no system in their arrangement. The highest hills are mostly yellow sand with now and then a pocket of clay, and where we have made excavations, a few stray boulders have been found. Perhaps a general description of a part of the country will not be out of place here.

The elevations given have been reduced to hights above Lake Michigan, by connecting our levels with an elevation above the lake at Cadillac, furnished me by Mr. G. S. Johnson, Chief Engineer of the G. R. & I. R. R.

Beginning at the Muskegon River in the northwestern part of Clare County, where the water in the river in section 16 T. 19 N. R. 6 W. has an elevation of 429 feet above the lake, the ground rises by two terraces westward to a long stretch of pine plains having a thin growth of brush and jack pines. The first terrace is about twenty feet, and the second about thirty-five feet above the river. The plains rise about twenty feet above the second terrace, and make an ascent of only twenty feet in two miles and a half.

Just over in the eastern part of Osceola County, the plains border the clay hills which are drained by the Middle Branch of

the Muskegon and its tributaries. These hills have an average elevation of 560 feet, but are very rolling and broken, and are frequently cut into by swamps running back from the streams. In the northern part of Osceola County, on the divide between the Middle Branch of the Muskegon and the West Branch of Clam River, the hills attain an elevation of 645 feet. This is eighty feet above the nearest tributary to the Middle Branch, and less than three quarters of a mile from it. Here the material is sand and gravel.

The ground then drop sixty feet in a mile and a half into the valley of the West Branch of the Clam. It then rises to the rough sand hills which have their summit in the southeastern part of Missaukee County and the southwestern part of Wexford County. The highest point in these hills over which we have run levels, is 818 feet. Other points which we missed must be thirty feet higher.

The highest point of grade on the Toledo, Ann Arbor & North Michigan Railway is among these hills (on section 18, T. 21 N. R. 8 W.), being 803 feet above Lake Michigan.

Dr. Winchell, in his "Topography of Michigan," says that the summit of the northwestern lobe of the Lower Peninsula is among these hills, but we have found places in the Brier Hills about twenty miles northwest of them which is ninety-seven feet higher.

These hills are composed mostly of yellow sand, and covered with a heavy growth of hemlock, maple, beech, birch, pine, elm, and a few other varieties of timber.

They are very rough and broken, cut up by deep dry ravines, running in various directions. Occasionally there is some clay at the bottom of a ravine which holds the water and forms a swamp.

They extend to Clam Lakes at Cadillac, and there present a bluff-like appearance. The elevation of the water in Little Clam Lake is 701.5 feet.

A large flat area lying about eighteen feet above Clam Lake stretches out north and west of Cadillac for a distance of six miles. On the west side of this flat piece there are a number of small lakes, surrounded by soft ground, with a very uncertain bottom.

From this soft ground the land rises rapidly to a plateau seventy-five feet higher. In the southwestern part of Wexford County this plateau terminates in a lot of hills very similar to those just described. They are divided by the Slagle Creek. Those on the north side of the creek are called the Brier Hill Range. The lowest point along the summit of this range which we were able to find, had an elevation of 915 feet. They extend westward to within half a mile of the Manistee River, which is about 740 feet below its summit.

The Slagle Creek is a very rapid stream, having a fall of 426 feet in ten miles. Between the creek and Brier Hills there is a

terrace having about the same fall as the creek, and widening as it approaches the Manistee.

The Manistee River has an elevation of 196.4 near Sherman Village, and is 55.4 feet lower seven miles down stream. The banks on the east side are more easily reached than those on the west side, where a range of hills from 225 to 300 feet above the water lie close to the river. The streams running from these hills into the Manistee are very short, and afford but little means of getting out of the valley.

Among the sand hills most of the ravines do not seem to have been formed by streams of water, and they often terminate abruptly at the foot of irregular knobs from twenty feet to a hundred feet higher.

The courses of these ravines and depressions through which you may at first hope to find a practicable route, are often so irregular that even if they did not lead into insurmountable knobs, they would be useless on account of alignment and the heavy earth-work necessary to cut through the ends of projecting hills.

Many times, a line running directly across these dry ravines will furnish longer tangents, easier grades, and less earth-work than could be found by following the best of them. Such a line might be rejected by a railroad official who has no eye for elevations, if he were to walk over it, unless he was provided with a profile of an actual survey, with an estimate of the work to be done, to convince him to the contrary.

I do not doubt but that engineers who build logging railroads have harder work to make their employees believe this than do engineers employed by railroads doing a general transportation business. When the Government corners are standing in the woods, the location of hills, streams, or anything else can be determined with sufficient accuracy, in the reconnaissance, by pacing.

When riding over section line highways, diagonal roads, or logging roads, distances may be roughly found by measuring the circumference of a buggy wheel, and counting its revolutions. Courses are taken with a pocket compass and comparative elevations with a barometer. While making this examination, lots of information will be offered by people claiming to be acquainted with the country. It will come in all degrees of utility, from the general statements of the old settler who says, "This is a mighty RAVINOUS country," to a minute description given by a lumberman who will tell each forty his route traverses. Another old settler will say that the only way you can get through, is by following a ravine where he chased a bear last season. One of these "only ravines" proved by actual measurement to be nearly a hundred feet higher than ground already selected as holding the best elevations and alignment in that vicinity.

Don't be led too far against your own judgment by men who offer themselves as guides and pilots in showing you through the woods, over what they consider a sure way through a place of difficult location. If the guide is a land owner, he will steer you to a place which will be convenient for him to deliver logs, without much regard for good railroad location. If he is ignorant, there is no telling where he will lead you. I remember one of the latter class who after traveling through the woods several hours, caught sight of his own chopping, and wondered whose clearing that was.

Perhaps when you arrive in town, some lawyer will tell you what a delightful time he had trout-fishing in a stream somewhere near the place you have been looking line, and describe to you a good place for location.

If you should go to the county records, you might find a bit of history running like this: Twenty years ago a mossback entered an eighty near the trout stream. Some years later a non-resident began action against him for cutting the pine off of the adjoining eighty; and still later a big mortgage, with a squeezing foreclosure clause, against a mossback's eighty, and in favor of this lawyer for defending him in his logging enterprise.

If you could look at a picture of the near future, which the lawyer looks at through a blue cloud of tobacco smoke while he sits scheming in his office, you might see a railroad skirting along a mill pond lined with factories. Just beyond is a big brick block with a conspicuous sign of "Lots for Sale" hanging out. Inside the corner office on the ground floor, the lawyer sits amusing his customers by telling them how he used to catch trout down near the mill-dam before there was a tree cut, while his busy clerks are hard at work writing the descriptions of his lots in blank deeds for them. But it does not follow that all schemers are lawyers.

I mention these cases to call attention to the information offered to an engineer when he is in active duty in the woods, that he may apply his knowledge of human nature to search out the motive of his informer, before any valuable time is wasted in finding him actuated by some selfish scheme.

The most reliable information can be found from lumbermen who have done business over a large area, and who have located sleigh roads for long hauls.

In the last year's work, the man who gave us the most accurate knowledge of the country was a farmer who hired out in one of our corps as an axman, and said he had been employed by Mr. Steele in Grand Traverse and Benzie counties, in similar duties. But he had to be questioned to draw out what he knew. It is as true here as elsewhere, that proffered and gratuitous information and opinions are of the least utility. When you want to know something that is of value, it must be sought from people who are too busy to hunt you up to tell you what they know.

While engaged in the reconnaissance, enough should be learned to enable the engineer to draw very accurate outlines of hills, table-lands, valleys, ravines, and to mark the streams on his map, so that he can lay out a course over which to run a preliminary survey, with the assurance that a practicable location can be found near it.

In places which are unusually rough, such as running from a table-land into a deep ravine or valley where the descent is made among abrupt and irregular hills, cut up by ravines and gulleys, or in passing over divides like those found in the southeastern part of Wexford County, and adjacent parts of Missaukee and Osceola counties, a definite course for a preliminary survey cannot be laid down at first.

Several courses are drawn, over which the chief or locating engineer walks with a pocket compass in his hand, and over what seems to be the best route for his purpose. He marks his course on the ground by breaking off brush and fixing pieces of paper on saplings and sticks. In settled weather, an aneroid barometer will be found of great service in aiding a person to keep desirable elevations, but in changing and stormy weather, a good guess will be much more trustworthy.

Then, frequently, several preliminary lines have to be run before the best route can be selected.

At this stage of the work, a party is put into the field to run the preliminary line. In places which present no special difficulties, the preliminary line can be run with the same care that is exercised in running a line for permanent location, cutting down everything, that the tangents may be free from swings.

When the nature of the ground indicates that the preliminary line cannot be adopted as the located line, short tangents are run, without joining them by curves. In the rough places, the broken brush and pieces of paper are followed, improving the line as much as possible. The several lines which have to be run in these places should be connected, and the levels run from the same datum line, in order that a comparison can be easily and quickly made, as soon as the notes have been platted.

Tie lines are used to connect the preliminary line with Government surveys every mile, if possible; but if much hunting is required to find the corners to run tie lines, it will be better to omit them until so large a corps will not be hindered.

If the preliminary work is done with a transit provided with a gradient screw and level attachment, it will afford much assistance in determining the course of lines where the best elevations can be held, etc., and oftentimes help to fix parts of the preliminary line so well that they can be adopted for location.

Mr. F. Hodgman, in his article on "Surveying for Railroads," read before this Society in 1883, tells of the advantages of the gradient screw, in advance of the leveler. In the spring-time,

when flooded districts have to be crossed, and the water is too deep to make measurements, instruct the head chainman in the use of the carpenter's "six-eight-and-ten rule" of laying out right angles. Let him select a hub at a convenient point on the farther side, and lay out his right angle. Turn off 5° 43′, and let him place another hub at the intersection of a line at right angles to the preliminary line at his first hub and the line which is deflected 5° 43′. Measure the distance between the hubs, and multiply it by ten for the unknown distance. The natural co tangent of this angle is 9.98931. In a distance of 1,000 feet, the error would be 1.07 feet, which is as close as most measurements are made in the woods on preliminary lines. This method of triangulation avoids chopping, and the computations are performed mentally, and the progress of the party interfered with but little. With a map drawn on a scale of 1,000 feet to the inch, and one or two good tie lines to begin with, courses of the preliminary lines laid down by the chief engineer can be scaled with a remarkable degree of accuracy by the aid of a good horn protractor. This saves the time of hunting up corners at quite a distance from the line, and calculating courses. When running around hills where pine choppings are covered with a thick growth of poplars and brush, so that the eye cannot penetrate more than six or seven rods, the locating engineer goes 800 or 1,000 feet ahead of the transit, selects the best place to run, and makes a noise, so that the line can be run toward him.

Every one knows that the valleys of streams should be followed when possible. Searle's "Field Engineering" and other text-books teach this and many other things which should be remembered in locating lines in the woods.

When the preliminary work has been finished, the line for location is run as soon as possible, using the map of the preliminary lines as the base of all work. I wish to emphasize what Mr. Hodgman says in his article, above referred to, against the "cut-and-try" method of locating.

Don't do it. It is expensive, takes lots of time, and seldom gives satisfactory results. Before going out to locate, everything which needs to be avoided, and all places which are desirable to use, should be located on the map.

In the woods, telemeters cannot be used to advantage. An engineer with two chainmen proceeds along the line, with no other instruments than a tape line and a pocket compass. Objects near the line can be located at right angles to a regular or plus station, by the engineer's placing himself in line, stretching out his arms in the direction of the preliminary line, then, with head erect, looking out straight.

If the line of vision does not strike the object to be located, move up or down the line until it does. With a little practice, a right angle can be approximated very accurately, and in less time than it would take a needle to settle. If the underbrush is thick,

or the object is too far from the line to be seen plainly, then the bearings are taken with a compass. Tie lines along section lines can be easily followed with a pocket compass, and with a fifty-foot tape line, good measurements may be obtained. When the topographical work has been completed, the notes are platted on the map of the preliminary line in camp or in the office. When this has been done, then all that you want and all that you don't want are arranged to show their exact relation to each other, plainer and better than could be expressed by volumes of words. If all of the work has been well done thus far, a location line can be drawn, and in most every instance followed.

No such progress can be made by cutting, trying, and backing out, when you have spent half a day with a full force of men to find that the position of some desirable spot has been miscalculated, or rather, misguessed.

Swings in located tangents are eye-sores which time does not cure, and almost everybody has too much pride in his work to allow any defect so noticeable to exist, if there is any way to prevent it.

It is easier to run a curve than a straight line. If any one doubts this statement, let him try it in a hilly country where there are occasional swamps, and all thickly timbered.

Short sights caused by ascending hills are to be avoided as fruitful sources of errors of this kind. The extra time used in cutting out overhanging limbs, so as to get a sight of at least 200 feet, will be well spent.

In swamps or in soft ground, long stakes are driven in the same direction the tripod legs are to stand, as a foundation for the instrument to rest upon to insure firmness while walking around the transit. A back flagman would better be promoted to the position of axman, for a back sight plumbed up behind the transit, with two pieces of thin card-board crossed and tacked to it, never neglects its duty. Sometimes it happens that two or three can be seen at a time, giving proof of the accuracy of the work.

The means employed to run a straight line would furnish subject-matter enough for an article too long to be included in this paper.

When an engineering force receives instructions to locate a line between two points, and to be ready to start a hundred men grading in a week, a thorough examination of the country cannot be made, and it will be wonderful if the best location is secured.

When such an order is issued, a connected location cannot be made. Parts of the line where men can be put to work to the best advantage are located first.

Under this condition, it is not always possible to have draughting tools when most needed to plat topographical notes, and whatever comes to hand must be used.

Once I received orders to locate a particular part of the line immediately, so that a gang of clearers could be started next day. Twenty miles of poor road lay between me and my drawing instruments. At a camp which was just starting in some deserted lumber shanties, I found an old rusty square and a piece of brown building paper. I appropriated them for my draughting. In the afternoon I went along the preliminary line, gathered notes, and in the evening platted them on the building paper. The map was drawn on a scale of 800 feet to the inch; angles were platted by using the table of natural tangents; and a piece of tough bark from a sapling, a pin, and a pencil, took the place of dividers to describe the curves.

The next morning I was able to run the located line ahead of the clearing gang.

GEO. L. WELLS.

WHAT A SPECIAL AGENT SAW IN OREGON AND NEBRASKA.

Mr. President and Gentlemen: —

I SEE that I am down on the programme to tell what I saw in Oregon and Nebraska while a special agent of the General Land Office, for the examination of surveys and the unlawful inclosure of the public land by cattle-men, and the fraudulent entry by pre-emption by the employees of these cattle-men or syndicates, in their interests. Being absent from home, I did not receive the programme from the Secretary in time to put down on paper what I saw, therefore I am compelled to give you a sort of extemporaneous speech of what I saw, to give you a general idea of the errors carelessly made in the public surveys in the State of Oregon, which I have represented by a diagram upon the blackboard.

I was instructed in the spring of 1883 to repair to Oregon and examine that portion of the Grande Ronde Guide Meridian, between the 4th St'd parallel S. and the 7th St'd parallel S., a distance of ninety-six miles, to ascertain where an error occurred of between two and two and one-half miles demonstrated by the running and marking of the 7th St'd parallel; and also the 6th St'd parallel west from the meridian, and nine townships adjoining near this line, in order that a correction could be made, also a full report made of my examination to the General Land Office.

Only field notes of the Grande Ronde Meridian, and the 6th St'd parallel south and extending west of said meridian, were furnished me.

My work was in Baker County, which is about 200 miles in length and 75 miles in breadth. I commenced work about latitude

44, and ran south, a full description of which will be given as my work progresses.

The *personnel* of my company consisted of two chainmen, a marker, a flagman, a cook, a teamster, and myself. At Boise City, Idaho, I provided myself with a heavy wagon drawn by four horses, a tent, cooking utensils, and provision to last five or six months; also necessary bedding. We left Boise City on May 4, 1883, and wended our way down the valley of Boise River, which is a very fertile valley, but sparsely settled; and the second day we reached Snake River, the boundary between Oregon and Idaho. This swift and turbulent stream, about one-half mile wide, we crossed on a ferry. It was then about sixty miles east of the point where I was to commence my labors. We were in a wild, unsettled country, rough, hilly, mountainous, stony, and rocky, destitute of timber and water, a wilderness, a treeless, God-forsaken waste. There was no one to inform me as to the location of the Grande Ronde Meridian, or how I was to get westward over the countless hills. They appeared impassable, but we knew we had to get there, so we pushed westward. We could make no calculations as to the distance we could make daily; that depended upon fuel and water. Our fuel was sage brush and grease wood, which grew from three to four feet high, the largest being not more than four inches in diameter at the root, with a broad, bushy top. The water when found was impregnated with alkali, which was not palatable. At last, by the assistance of a cow boy, we found a township corner twelve miles east of the much coveted meridian, and when we reached it, we were eighteen miles north of the 4th St'd parallel. This we re-traced till within six miles of the initial point, when we encountered the vast hills that bounded the Malheur River, — rough, rocky, steep, and treeless, and giving an impression, upon the mind of a common Michigan man, of desolation absolute. Now came the tug of war, to get our wagon and supplies down into the valley of the Malheur River, which we afterwards learned was very narrow, and the stream very swift. I instructed the teamster and cook to look for a canyon or pass through these hills into the Malheur Valley, and we would continue our course south. We soon found that it was impossible for us to keep the line of the meridian, on account of the local attraction from the basalt rock, which was very hard and flinty, and strongly impregnated with iron; — we were lost in these vast hills! About three o'clock we concluded that we would better look for our wagon. We took our back track, and, to our surprise, at dark we were obliged to camp. I had instructed our cook to fire a gun every ten minutes after six o'clock for two hours, so that we could find where he had camped. He obeyed orders, but not a sound could we hear in those everlasting hills, except the yelp of the coyote, or prairie wolf. I said we camped,

but we only stopped, because darkness compelled us to; not a drop of water near, not a morsel to eat, and not a blanket or anything to lie down upon. We built a fire with green sage brush, which we cut with a jack-knife, and tried to keep warm; but we burned upon one side while we chilled upon the other, — at least it was more comfortable to change sides. The next morning at twilight we discovered that the ground was white with frost. That was a long, dreary, hungry night, and I thought of "sweet home" in Michigan, and I thought of words some would term adjectives (but of course I did not use them) as I laid upon the cold, hard ground, with nothing but the canopy of heaven over me, turning over trying to thaw out.

About ten o'clock the next day, by the assistance of the cook's Winchester, which made the welkin ring, we found our wagon, and did full justice to pork and beans, taking our supper and breakfast together. The remainder of the day we spent in searching for a place to get our wagon down into the valley of the Malheur River. During the day we discovered what we learned afterward to be the trail made by the hundred wagons of a colony that emigrated from Missouri in 1842 to Willamette Valley in Oregon, and the ruts made by the wheels could be easily traced yet. At the point where we found our wagon, we found the remains of wagons, stoves, and cooking utensils; for these same emigrants became lost when near their journey's end, got out of provisions, and were living upon the flesh of their mules, when friends residing in the Willamette Valley searched for them and found them, and rescued them from starvation. Somewhere upon their trail they found gold in large quantities, but it had no value when they were lost, and on the eve of starvation. Several of that party have prospected for that find from year to year, but their search had been fruitless up to 1884.

When once in the Malheur Valley, we were about ten miles up stream from where we found the line of the Grande Ronde Meridian. We retraced our steps to find the point we left the night before. By diligent search, and by the aid of piles of stone which we had placed upon the highest points, we found it, and by the aid of range poles with which we had previously provided ourselves (the magnetic needle had ceased to be of any use to us, on account of local attraction), we were enabled to find the initial point, being the 4th St'd and the corner to township 20 S., between ranges 39 and 40 east, and one mile south of the Malheur River. Finding that we could not trace the meridian farther, and that our wagon was no longer available, the country being so rough and broken, I at once repaired to Malheur City, a small mining town that we had learned was about fifty miles north, ordered a new Mountain Transit with solar attachment from the well-known house of W. & L. E. Gurley, of Troy, N. Y., and purchased five ponies, one mule, and pack saddles for nine horses. The mule I rode myself, it

being much surer footed than a horse, which was of vital importance to me when climbing the steep hills and rocky peaks, in places almost impassable, that we were to encounter upon the route. Some of them were composed of shale rock which would give way under our feet, and to avoid them was next to impossible.

I had also to examine the 6th St'd parallel west for twenty-four miles, to ascertain if it was a true east-and-west line, as the error might have occurred in running it. During the time I was waiting for the arrival of my Mountain Transit with solar attachment, we employed our time in trying to trace the meridian with range poles, to see if we could discover any corners on this line; but the search was fruitless. This line for twenty-four miles was run in the fall of 1864, but the surveyors were scared out by the Bannock Indians, who were on the war-path. The work was resumed and finished in 1866. Field notes of this meridian and the 6th St'd parallel S. were furnished me, and this line was represented to be a N. and S. line, with the exception of six miles offset to the east to avoid a spur of the Blue Mountains.

In due course of time my solar came, and we ran twenty-four miles, and fell east of the township corners on meridian three chains; ran six miles farther south, found the corners well marked, and intersected what should have been the 5th St'd parallel, which I found upon investigation to start forty chains west. Thence I ran south eighteen miles; thence an offset east of six miles; thence south twelve miles to the east end of the 6th St'd parallel south. From this point seven miles south, and a half mile east, the 6th St'd parallel S. runs east, being an offset east of one-half mile. This parallel is located one mile farther south than it ought to have been, but there are no notes given of the first mile after leaving the 6th parallel. Evidently it was not measured. Here was an error of one mile south on the meridian. At one-half mile east and one mile south of 6th parallel I found the meridian, and then started south, and at a distance of twelve miles I was lost; could find no trace of the meridian. Did I say lost? I was not lost, it was the meridian; but after a search of several days, thirty chains farther south, and 6.50 chains east, I again found the meridian, and traced it south till it intersected the 7th St'd parallel S. at a distance of eighteen miles. In running this line, several errors cropped out besides the excess of about 1.28 chains. In the last eighteen miles there was about one chain to the mile excess. The west line of township 30 S. of R. 41 E. was not run by the United States Deputy Surveyor, as he reported to the Surveyor General of Oregon that he could not find the Grande Ronde Meridian, because the Indians undoubtedly had destroyed all the corners; hence this error. The south line of said township commences one mile too far south; hence another error.

Also the west line of township 32 S., R. 41 E. is one and one-half miles east from the meridian, and starts south 30 chains too

far. I found in my examination that the N. E. corner of T. 33 S., R. 41 E., extended 6.60 chains E. of the S. E. corner of T. 32 S., R. 41 E., and 30 chains south, which is a very grave error, — of course the 7th St'd parallel S. is established one mile too far south. I examined the 6th St'd parallel S. west and found it a correct line.

I examined T. 26 S. and R. 37 E., and found it had never been surveyed. I suppose that this order was to convince the authorities that ordered the survey whether I made up my field notes in the field or camp, but the result was that I was not "caught napping."

In my examination of the interior lines of T. 25 S., R. 39 E., running N. and S., when I struck the north town line, I was 40 chains west of the section corner, caused by the set-off west on the south boundary. This will produce an error in all the townships west of this. The W. half of this township never was surveyed, being exceedingly rough. A United States deputy surveyor had a contract of surveying adjoining my work. I saw him at work, and he ran east, west, south, and north in subdividing, as most convenient, hardly ever setting one-fourth post corners; never, when he did not chain.

This, after two seasons, finished my examination of the work assigned me by the Commissioner of the General Land Office, when I made a full and comprehensive report, as ordered by that office. My work was very much retarded by the errors that I found in the field. I was not able to examine more than four miles a day, on an average. Our work was a great distance from fuel and water, as there was no water excepting streams that were very few, and water standing in the pools, sinking and not to be seen again for miles. There was no timber excepting some little cottonwood along the streams, some willow, sage brush, and grasswood for fuel. A kind of bunch-grass which is very nutritious grows upon the hills and in the valleys, hence the raising of cattle and horses has been a great industry in the past, and a source of much profit; but this bunch-grass is fast being trodden and eaten out. This grass begins to start in February, and is dead and dried up by the first of July, but there being no rain or dews, retains its nutriment till new grass comes. Young cattle and horses do not have to be fed.

The streams are fed by the melting of the snow upon the mountains, and the arable lands of the valleys are irrigated by the same.

The inhabitants have to depend altogether upon irrigation, as there are no rains; and thunder and lightning are unknown. Wheat, barley, oats, and potatoes yield enormously; but the climate is too cool for corn, as it will not ripen. Wheat yields from fifty to sixty bushels per acre, which would seem to the Michigander to be incredible. Winter wheat is the only kind raised. The winters are mild, the thermometer seldom reaching zero, so it does not freeze out. Water from the ditches can be put on or taken off at

pleasure, so it is not affected by drouth. The nights are cool, which is favorable to the growth of wheat. There are no rains or winds to destroy the blossom. The heads are very long, and every place in the head has a kernel. Silica in the soil stiffens the straw so that it never lodges. The kernels are very large, plump, and heavy. Cattle and horses have to be herded, as there are no fences.

The Malheur River proper has three branches, is shallow, very wide and swift, and empties into the Snake River. Some of its fish are of the salmon species that come from the Columbia River, via the Snake. Its valleys are very narrow, fringed, and hemmed in by rugged, steep bluffs. The Owyhee is a very swift river, narrow and shallow, with steep, rugged bluffs. The Snake on the east is a very swift, boisterous river, the bottom being filled with rocks, and in consequence is not navigable; and I doubt whether any steamboat could stem the current, if free from rocks.

We saw several hot, boiling springs, and the wonder was whether caused by chemicals or internal fires. This country, no doubt, has been subject to great volcanic eruptions in ages past, as I found stone of a flinty nature that showed the effects of fervent heat, and sea shells on the highest peaks.

The climate of Eastern Oregon is very mild, all that one could wish. The nights are cool, requiring considerable covering, but in the morning one rises refreshed, and the air is balmy and bracing. No bilious diseases, no stretching and yawning, as in Michigan; one always has a good appetite as soon as out of bed. After we left Boise City, when we put up our tent to sleep in, we invited our teamster to "turn in" with us, but he declined, saying that he "preferred the pure air out doors." Before we reached the meridian, we ceased to put up our tent, and camped out till about the first of November. We had plenty of venison and antelope and jack rabbit that our cook killed with his Winchester; also trout and salmon. The boys spent their Sundays playing pedro, as we got nothing to read for weeks, being from 50 to 100 miles from a post-office. I busied myself straightening up my field notes.

Malheur City is a small mining town, and the mines that have been abandoned by the whites are worked by Chinamen. Water was brought in ditches and flumes for over 100 miles, constructed by a company from Chicago at a cost of $250,000. I became acquainted with a Chinaman, a contractor, who could speak very good English, and he gave me much valuable information about China and the Mongolian race. These Mongolians were a very industrious and inoffensive race. Notwithstanding their foul habitations, they practiced daily ablutions. They bathe as if it were a sacred duty, and in the winter they would cut holes through the ice to find the necessary water. The cue they universally wear, they regard with patriotic pride. It and the tonsure were introduced into China in 1644, as a mark of acceptance of subjection to

the Tartar rule, and enforced by the favor of the court; and those who refused to wear it were in some cases put to death. At length the mark of derision became the badge of honor, and now every Celestial carries this flag of his country, no less dear than his own head. They worship idols, and are slow to be converted to Christianity, and slow to learn to speak our language, or to understand it. Here is a specimen of some poetry, attributed to one of the Chinese scholars while being taught at a Christian mission: —

> "How doth the little busy bee
> Delight to bark and bite,
> And gather honey all the day,
> And eat it up at night."

While in Malheur City, I was asked by a United States deputy surveyor if I did not want the best cup of tea that I ever tasted. If I did, he said, just step into a Chinese restaurant, where I would get it. I consented, and after being comfortably seated at the table, I was asked if I did not want some soup. I told the waiter that I would take some, and it was so good that I took the second pint bowl, and I thought it the best soup I had ever tasted. After leaving, the deputy asked me how I liked the soup, and informed me that it was rat soup. "Yes, made of rats!" he said with emphasis, and about then and there my stomach heaved and rolled, while my friend tried to console me by saying that I had eaten more filthy things than this; for illustration, the dung-hill fowl and the hog. The illustration was well taken, but that did not settle my stomach. It required time, and it brought to my mind the story of the old lady who said, as she kissed the cow, "It is just as one is brought up."

These Chinamen who were digging for gold found the tooth of a mastodon, that weighed four pounds. It was ten feet from the surface, in gravel, in a good state of preservation, and had to all appearance lain there for ages. The climate of Eastern Oregon was all that one could desire, — days not overly hot, very temperate, the nights cool, requiring considerable covering, no mosquitoes, no reptiles. The air is pure and exhilarating, and it is a pleasure before sunrise to inflate the lungs with this pure air; but one has to be careful, if his vest is buttoned up tight, that he does not in a thoughtless moment burst the buttons off.

During the examination, before the arrival of my solar, as we were riding in single file, some cow-boys from a ranch about three miles distant discovered us in the distance, and also seeing me seated upon my mule upon a peak about 500 hundred feet high, "taking the country in," they took me to be the "big Injun," watching the movements of the whites. They reported to the settlers about twenty miles west of us that there were Indians in the country, and that they would better fly for safety. In the excitement, they left everything, and went to a fort that had been

built by Uncle Sam upon the Malheur Indian Reservation, the Indians having been removed previously. Men well armed came to watch the movements of "the Indians," but they were sure to keep their distance, so as to be doubly safe. One evening, two of my employees went to the ranch before mentioned to get some buttermilk, and to their astonishment found two cow-boys armed with Winchesters, standing as sentinels or guards, while several inside were eating supper with Winchesters at their sides. They informed the boys that there were Indians prowling about, and that they were liable to be attacked and massacred at any time. When they had fully explained what they had seen, and the boys had informed them that it was a company of surveyors that they had seen, they were surprised, and could hardly be made to believe it. They intended that night to make a raid upon us, and probably some of us would have been made to "bite the dust." Had it not been for buttermilk some of us would have gone "where the woodbine twineth." This occurrence made some of my boys timorsome, as they said the Indians might be lurking around, for aught we knew. This Indian scare even crept into the newspapers, but the truth of the matter did not get there. When the truth of the scare was reported at the fort, the settlers returned to their homes.

One day while riding horseback, I saw in the distance what appeared to be a city with its lofty spires. On approaching it, I found it to be a very curious formation, standing out in the valley of the Malheur River in bold relief from the surrounding bluffs, several hundred feet high, composed of several layers of sandstone, chalk, and basalt rock, and having been worn into almost every shape that the imagination might picture, by floods and stormy weather, and the hand of time had carved it into the most curious and fantastic forms, lofty domes, pinnacles, and fluted columns, resembling at a distance the ruins of an ancient city or cathedral in the midst of general desolation.

Having received a telegram from the General Land Office to report at Valentine, Neb., for duty, I then left Oregon; but I will say that on my way, crossing Snake River, a bridge was being built by the Oregon Short Line, having three abutments sixty feet high, the center one being very difficult of construction, as the river was so swift. They were constructed of cut stone shipped from Cleveland, Ohio. The bridge was to be built of iron, but the chief engineer of construction, who had been chief during the construction of the Union Pacific, had made a mistake of one foot in length of one span, which delayed the construction for some time. That engineer was informed that his services were no longer wanted.

I arrived at Valentine, a place of 600 inhabitants, situated upon, and at the then terminus of, the Sioux City and Pacific R. R., west of Omaha, Neb., 300 miles. There I found instructions to provide

myself with the necessary outfit and reliable men, whom I would better arm well, and proceed at once to northwest Nebraska, giving the township ranges, etc., 200 miles distant, to make an accurate survey of all inclosures by wire fence and otherwise, of Government lands by cattle-men, and also to examine all fraudulent entries, homesteads, preemptions, etc., as it had been reported to that office that Government lands were being unlawfully fenced in by cattle-men, and fraudulent entries made, and that homesteaders and preemptioners were being "frozen out," or forcibly ejected, if they attempted to settle within the inclosures. At the close, I was to make a clear and explicit report of the result of my examination. The United States deputy surveyor, who had the season before surveyed that country, had cut the wire fences to allow the teams to pass, and had let the cattle-men's stock away, requiring much time and expense to recover them. By so doing, the deputy surveyor had incurred their displeasure, and they had placed notices upon the fences, "Death to the son-of-a-bitch that again cuts our wire fences." Hence the order from the Department to arm my men to fight. I had not enlisted to fight, — no bounties were offered, — but having learned the character of cattle men and cow-boys while in Oregon, I preferred to adopt the pacific course, and I found that it won. The latch string of the cabin I ever found hanging on the outside of the cabin door, and the inmates were always ready to give us any information desired, and to give us shelter or anything we needed.

I hired a man, with a wagon and four good horses, who acted as teamster and cook, and three other men, two chainmen and a flagman; bought a tent, stove, and provisions to last us the round trip. We took along about forty bushels of corn to feed our teams, started out on October 6, 1884, and reached Pine Ridge, Indian Agency, 120 miles distant, on the 12th (the country unsettled), just over into the southern part of Dakota. Dr. Mc Gillicuddy, agent, received us kindly, and entertained us very pleasantly, giving me some really valuable information about the character of the Sioux Indians. He pointed out to me the Indian chief that claimed to have killed Gen. Custer. He was a sour, coarse, revengeful-looking being, painted, wearing feathers on his head, and beads, cheap jewelry, etc., on different parts of his person; calico shirt, blanket, buckskin leggings, and moccasins. He informed me that there were about 7,000 Indians, old and young. The Government clothes and feeds them. They consume the beef of over 6,000 three-year-old steers yearly. The Indians kill and dress the beef, and it is then dealt out by the Commissary. The Indians are well fed, having in addition, flour, sugar, coffee, yeast, salaratus, and even soap, and the necessary cooking utensils. At this Agency there is a police force of 100 Indians, well armed, drilled, and dressed in Uncle Sam's uniform, and paid by that gentleman. There are also two schools here to teach them to read, write, cook,

and sew, taught by two maidens from Chicago. I spent half a day in the school, and it was amusing to see the proficiency they made in making pictures, but they were slow in learning our language, hence slow to learn to read and to spell. Several have been sent to Carlisle, Pa., to school, but the confinement did not agree with them, and they often returned with consumption, and soon died.

The Government furnished these Sioux with 500 new wagons and double harnesses, and they broke their ponies and drew their flour and groceries from Valentine at $1.25 per hundred, and the Government paid them for it. Some of them dressed like white men. When I was there, 6,000 steers were delivered by contractors at five cents per pound, to a United States Officer (Captain) in the regular army, and weighed, averaging 1,000 lbs. each. Mc Gillicuddy was afterwards accused, upon pretty good authority, of manipulating the scales so as to make each steer weigh 25 pounds heavier, which would make 150,000 pounds gain, and at 5 cents a pound would amount to $7,500, which was pocketed by the agent and seller; but inasmuch as it came out of Uncle Sam, it was all right.

Congress sent a committee of seven members of Congress to investigate the several Indian agents in the northwest, and while investigating this Agency, taking testimony, etc., one Indian contradicted another. The lie passed, and tomahawks were raised and knives drawn, and for a few minutes an outbreak seemed imminent, but Mc Gillicuddy rushed in bravely and quelled the seeming outbreak. It was said that Mc Gillicuddy told the committee that his timely interposition saved an outbreak, and had there been one at that time, not a white would have been left to tell the story. The next morning that committee left the business they were expected to finish. When they arrived at Valentine, I talked with several members of the commission, and from the tone of their talk they believed that they had barely escaped with their scalps. I talked with Holman, Chairman of the Commission, who was from Indiana. He is rather small in stature, aged about 65 years, and is known in Congress as the "Chronic Objector," as he will not allow any bills to come up unless in regular order. He said that he slept with both eyes "wide open," after he saw those tomahawks and long knives gleam in the air. The old man was evidently scared. They all thought their time had come. I never learned what they reported in this special case to Congress, but I think that they were evidently "sold out" cheap.

While visiting this reservation, Dr. Mc Gullicuddy took me to some Indian tents. There I saw squaws at work dressing or preparing buffalo-robes for market. He informed me that when these hides were first taken from the animals, they must be stretched and dried flesh side up. If not in this condition, when the squaws received them they have to do it. After they are thoroughly dried, the squaws take all the flesh off and reduce

them to an even thickness with an instrument, which for want of a better name, may be termed an adz. It was a little thin piece of iron about two inches long on the edge, and two and one-half inches deep. This was firmly tied to a piece of the thigh bone of an elk, and was used the same as a garden hoe. When the required thickness was obtained, the flesh side was covered with a preparation of lard, soap, and salt, and the robe was then rolled up and laid by for two or three days. It has then to be unrolled and again stretched on a frame like a quilt, with the flesh side to the sun. In this shape it was scraped with a thin oval-shaped piece of iron or steel, resembling a kitchen chopping-knife without the handle; this process usually lasted about two days. The robe was then taken from the frame, and drawn across a rope until it became thoroughly dry and soft. This last process made it very pliable, but required a good deal of time and strength; but it rendered the robe ready for market. I bought a very large one, costing eleven dollars. I brought it home and could have sold it for forty dollars. The squaws laughed when I pulled out my note book and began to write, being evidently as much astonished and interested as I was. They looked with wonder at the book, pencil, and the words I wrote. The lazy bucks just stood and looked on, while evidently the squaws always did the work, were willing to do it, and the Indians willing that they should. An Indian is constitutionally opposed to labor. He is evidently "tired" all the time. It is my opinion that the Indians will never make farmers, dividing their lands in severalty and breaking up their tribal relations will be a failure. But this is a problem yet to be solved, and it has been the study of the best minds in the nation for years.

After we left the Agency, the first night that we camped we saw about a dozen squaws with a span of ponies and a wagon without any box upon it, only a few boards. They were gathering some kind of berries, but their team balked coming down the hill. Not a step would they take downward. The squaws hollowed, and yelled, and whipped, and tried to push them down hill, but they would only push backwards (the first time I ever saw horses balk coming down hill). I sent my boys, and told them to unhitch the team from the wagon and draw it down. They did so, and the squaws laughed and showed their appreciation as best they could. They camped near us, and used water from the spring. The next morning they had their breakfast before we did, and a young squaw, probably eighteen years of age, her hair nicely braided and her head and face painted, and dressed in a sort of blue woolen Indian cloth, with beads around her neck, and brass finger rings on her fingers, in company with her mother, paid our camp a visit while we were eating breakfast, and stood around our camp fire. This young maiden watched the boys, and after breakfast she, by direction of the old lady, handed each some berries, when the old lady laughed and seemed very much pleased.

What they meant by this we could not conjecture, unless it was Indian love. We left that morning, "Westward, Ho!" and arrived that night at Camp Robinson, where about 1,000 United States troops were stationed to watch Indians.

On the 16th of October, we were in Hot Creek Valley, a distance of 200 miles west of Valentine, where I found six inclosures, averaging from 5,000 to 25,000 acres, and pasturing from 400 to 1,000 horses, and from 5,000 to 15,000 head of cattle each; but they pastured the surrounding country, only keeping these inclosures for their riding horses and the fat cattle that were to be sold. I then went south over a spur of the Black Hills, about twenty miles on to the Niobrara River, and surveyed around a ranch that contained 62,000 acres in its inclosure, and was forty-five miles around it. We had to camp on one side of the river, where we could get wood and water. It took us ten days, and as we were obliged to travel from ten to fifteen miles each day to our work, we took a team. We borrowed dry pine wood of the owners of the ranch, who had to draw it fifteen miles from a spur of the Black Hills. This company, of which A. S. Hewitt, of New York City, was president, had 16,000 head of cattle and 1,500 head of horses. This ranch bordered on and extended into Wyoming. Ten miles from this, down the valley of Niobrara River, they had another ranch of 16,000 acres; they had very good buildings upon all these ranches, built of pine logs taken out of the Black Hills, which were timbered with pine, and would afford plenty of timber and lumber for the surrounding country for years. The land was generally prairie, which raised a great amount of grass; and the pasturage was rich, but in many places the water was impregnated with alkali. The country was well watered with good springs and brooks, and I think, all things considered, is the best part of Nebraska.

During the summer of 1885, nearly this whole country was preempted and homesteaded, and by order of the General Land Office, the wire fences had to be taken down, and then there was an emigration to Montana, to "other pastures new." In the fall of 1886, the Sioux City & Pacific R. R. had extended their road from Valentine west up the valley of the Niobrara River, and built a depot where we camped at the A. S. Hewitt ranch.

We found many fraudulent preemptions by employees of these cattle-men, that I prevented from proving up at the Land Office at Valentine, being in that land district, and being located some six months at Valentine. I prevented many frauds on Government lands.

We found in one place, called the "Bad Lands," that the ground in the spring was so soft that it was impassable with wagons, and nearly so on horse-back, being of a clayey nature, soft and sticky, and said to load the wheels down in going a short distance, so that the wagon could not be moved. It would shake

like liver, but in the summer it became hard. Petrified frogs, mud-turtles, and fish were numerous. I saw a petrified mud-turtle that weighed 25 lbs. I also saw hundreds of the heads of buffaloes which had probably been killed by the Indians, but I saw none alive. They are of the past, — have followed in the wake of the mastodon.

I think that most of the land passed over by me is better adapted to raising stock than grain, as the elevation is too great for corn. Good wheat has been raised, and no country excels it in raising potatoes, barley, and oats.

Wild game is plenty, such as deer, antelope, wild geese, ducks, prairie chickens, and grouse, and the streams abound with excellent fish.

I finished my examination on the 20th of November, and turned my face toward Valentine. The weather had become cold and disagreeable to camp out. We were just one month too late, and on the morning of the 24th, six inches of snow laid upon the ground, and the thermometer was 12° below zero. Then we appreciated our tent and stove. We arrived at Valentine, Dec. 31, well satisfied that we could now appreciate comfortable quarters.

ISAAC TELLER.

Mr. Appleton. — "Are these river valleys generally fenced in?"

Mr. Teller. — "No, sir, they are not. The valleys are generally very narrow."

Mr. Appleton. — "Each valley, then, would have but one owner, would it?"

Mr. Teller. — "In some cases it had several owners."

Mr. Appleton. — "Are these valley ranches large? Are they not generally owned by poor people?"

Mr. Teller. — "Yes, sir, generally owned by poor people. The lands in those valleys are extremely rich and fertile."

Mr. Appleton. — "Have they any legal claim on the land?"

Mr. Teller. — "They are mostly homesteaders."

Mr. Appleton. — "They have no schools, have they?"

Mr. Teller. — "No, sir."

Mr. Appleton. — "Where did you find the pine?"

Mr. Teller. — "In northwestern Oregon. The geological aspect of the country looks as though it had been thrown up at some time. I found shells that were carried there from the sea. The air was very pure, and you could look upon the mountains a hundred miles distant, and sometimes we saw the mirage. At one place when I was traveling on horse-back one day, I saw in the distance what appeared like a city, but come to get up to it, it was columns of basalt, which looked like church spires."

STEEL TAPES.

It doubtless may be a matter of some interest to surveyors to see a comparison of the steel tapes sold as accurate measures, with a standard United States measure.

The standard in question is a brass yard of a certain number, furnished our State by the Treasury Department at Washington, as a standard yard. It is of exact length, at a temperature of 58.4° F., and is both a line and end measure.

The tapes in question were kept in the same room with the standard for some time, and were of the same temperature as the standard when making the test.

Three tapes were tested, No. 1 being an English tape, with graduations etched on the steel. No. 2 was graduated by soldering on babbit metal, and stamping the graduation on that. No. 3 is a tape graduated by puncturing holes through the body of the tape, and putting a rivet through at every point.

The report of my assistant, showing how the tapes were calibrated, is respectfully submitted. Yours,

R. C. Carpenter.

The accuracy of three different makes of steel tapes was tested as follows, with regard to graduation, calibrating them with a United States standard yard measure: The method of making the test was to have a person hold the back end of the tape exactly at the mark, while another exerted a strain of ten pounds on the tape, and a third person noted the variations. We were able to test only forty-five feet of the tape No. 1, owing to a break just beyond the forty-fifth foot. The following tables will show the variation for each foot in decimals of one inch.

TABLE SHOWING VARIATION OF THE NO. 1 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	+ .035	13	+ .05	24	+ .03	35	+ .01
2	+ .04	14	+ .04	25	+ .03	36	+ .005
3	+ .06	15	+ .05	26	+ .025	37	+ .005
4	+ .06	16	+ .05	27	+ .02	38	+ .005
5	+ .06	17	+ .05	28	+ .03	39	.000
6	+ .05	18	+ .04	29	+ .03	40	.000
7	+ .06	19	+ .04	30	+ .03	41	— .005
8	+ .07	20	+ .035	31	+ .035	42	— .01
9	+ .06	21	+ .03	32	+ .025	43	— .01
10	+ .065	22	+ .035	33	+ .01	44	— .01
11	+ .07	23	+ .04	34	+ .01	45	— .015
12	+ .05						

The length of No. 1 Tape is 44 feet 11.985 inches; temperature, 70° F. Total error, .015 inches.

TABLE SHOWING THE VARIATION OF THE NO. 2 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	+ .02	14	— .01	27	+ .00	39	— .01
2	+ .01	15	— .01	28	.00	40	— .01
3	.00	16	— .01	29	.00	41	— .02
4	.00	17	.00	30	.00	42	.00
5	— .03	18	.00	31	.00	43	.00
6	— .03	19	+ .01	32	+ .01	44	+ .01
7	— .02	20	+ .01	33	.00	45	+ .02
8	— .02	21	.00	34	.00	46	+ .02
9	— .02	22	.00	35	.00	47	+ .02
10	— .03	23	+ .01	36	.00	48	.00
11	— .03	24	.00	37	.00	49	.00
12	— .03	25	+ .01	38	.00	50	— .01
13	— .02	26	+ .01				

The length of No. 2 Tape is 49 feet 11.99 inches; temperature, 70° F.

TABLE SHOWING THE VARIATION OF THE NO. 3 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	— .04	14	— .055	27	— .200	39	— .190
2	— .05	15	.065	28	— .230	40	— .240
3	— .03	16	— .105	29	— .200	41	— .290
4	— .05	17	.065	30	— .220	42	— .210
5	— .03	18	— .095	31	— .270	43	— .230
6	— .05	19	— .095	32	— .220	44	— .250
7	— .01	20	— .135	33	— .220	45	— .260
8	— .05	21	— .155	34	— .220	46	— .260
9	— .05	22	— .155	35	— .240	47	— .260
10	— .09	23	— .155	36	— .230	48	— .250
11	— .10	24	— .155	37	— .170	49	— .270
12	— .055	25	— .205	38	— .180	50	— .390
13	— .055	26	— .235				

The length of No. 3 Tape is 49 feet 11.61 inches; temperature, 70° F.

Respectfully submitted,

O. C. HOLLISTER.

SUPREME COURT DECISIONS.

THE following abstract of Supreme Court Decisions is compiled from the "American Digest," and published by permission of the West Publishing Co., of St. Paul, Minn.: —

Where there is a dispute as to the true division line between adjoining proprietors, and they agree on a permanent boundary, and take possession accordingly, the agreement is binding on them, and those claiming under them; and such agreement is not within the statute of frauds. — *Following Jacobs vs. Moseley, 4 S. W. 135; Atchison vs. Pease (Mo.), 10 S. W. 159.*

In ascertaining the boundaries of a city lot bordering on a street, the lines of the street as located by the city engineer, and acquiesced in by the city authorities and the public for many years, are to be preferred to those of a more recent survey. — *Koenigs vs. Jung (Wis.), 40 N. W. 801.*

In taking distances from one point to another on navigable water, the measurement is by its meanders, and not in a direct line. — *Rayburn vs. Winant (Or.), 18 Pac. 588.*

Where there are well-established monuments of a boundary, and the line run from the point of beginning by courses and distance does not conform to one of the natural calls, whereas by starting from the other point, all the natural calls are answered, the first course and distance from the point of beginning must give way, especially when by following it the line is taken out in an open valley where there is no apparent reason for its frequent changes of course, but taken the other way it runs along the base of mountains, which render such changes necessary. — *Hughes vs. Cawthorn, 35 F. 248.*

The Government plat and field notes described the meander line of a tract of land as being at the Missouri River. In fact, the meander line was not run along the river, but along a bayou, some distance from the river; and land between the bayou and the river, though in existence at the time of the survey, had never been surveyed. *Held,* that such land did not pass by a conveyance from the government of the surveyed tract. — *Glenn vs. Jeffrey (Iowa), 39 N. W. 160.*

A patent conveyed the west fraction of a fractional quarter-section containing 23.10 acres. West of such land was a large running slough, or navigable arm of the Mississippi River. In the Government survey of the fractional quarter, a meander line was run along the east bank of the slough, but was not marked on the Government plat. The slough was marked on the map as the west boundary of the land. *Held,* that the meander line was not a boundary, and that the patent included an island lying between

the land described and the middle of the slough, such island never having been surveyed or platted by the general Government. — *Fuller vs. Dauphin (Ill.), 16 N. E. 917.*

A Government "lot" was platted as bounded on the north by a meandered water-course, whose actual shore line was about 320.6 feet north of the meandered line, the lot being merely described as numbered on the plat. *Held*, that its east line ran due north until it intersected the actual shore line, and thence to the middle thread of the stream, at right angles with such thread, and did not turn at its point of intersection with the meander line; the latter line being run, not as a boundary, but merely to determine the number of acres in the lot. — *Menasha Wooden-Ware Co. vs. Lawson (Wis.), 36 N. W. 412.*

Where it appears that a street was originally laid out 23 feet in width, and that it is that width except at the place of plaintiff's alleged encroachment of 23 inches, and that certain trees cut down inside plaintiff's fence were at one time outside a narrow pavement used by the city, and that plaintiff's lot contains all his deed calls for, without said 23 inches, the line as claimed by the city is sufficiently established. — *Yates vs. Town of Warrenton (Va.), 4 S. E. 818.*

Where the dispute is as to whether a certain fence or an adjacent ditch is the division line, it is error to admit the testimony as to what witness supposed, or what was generally supposed, to be the line, though witness had been long and intimately acquainted with the premises. — *Beecher vs. Galvin (Mich.), 39 N. W. 469.*

The statement of a witness that the ditch was acquiesced in as the dividing line between the predecessors in estate of the parties litigant; that it was tacitly consented to by all parties for the reason that no one ever obstructed, or put a fence in the ditch, is inadmissible as being the witness's conclusion. — *Idem.*

A deed conveyed certain lands, "excepting and reserving therefrom 68 feet of land off from the east end of said described premises." The vendor retained possession of a lot 68 feet wide, along the whole east side of the lands, and put the purchaser in possession of the remainder. They built a fence and dug a well on the line thus fixed. The vendor built a house and barn on the portion held by him, and after many years, conveyed it, as 68 feet wide. *Held*, from the acts of the parties, and the surrounding circumstances, that the exception was meant to reserve 68 feet in width along the east end of the lot, and not 68 feet, which would be a strip but six inches wide. — *Montfort vs. Stevens (Mich.), 35 N. W. 827.*

Plaintiff claimed title under a survey by the United States in 1868, and a certificate of purchase from the State describing the

land as in section 18. Defendant showed that the first survey proving incorrect, a new survey was made in 1880, when defendant made a homestead entry upon the land then described as N. W. ¼ section 17. *Held*, that as plaintiff had never been in actual possession of the land, nor had it been listed to the State when he purchased, nor prior to the second survey, the title would follow the second survey. — *Murphy vs. Sumner (Cal.), 16 Pac. 13.*

When, in the description in a deed, reference is made to a plat, it may be used to identify the lands referred to, though it does not conform to the statute, and is not duly certified. — *Sanborn vs. Mueller (Minn.), 35 N. W. 666.*

Where, in an office survey, a line was described as running from a fixed point south to another point described, but not established on the ground, which did not lie in the designated course, it being intended that the line should run north and south, *held*, that the second point named being descriptive, and not locative, should be disregarded, and that the line should follow the course named. — *Lilley vs. Blum (Tex.), 6 S. W. 279.*

In 1847, adjoining lots 51 and 54 were conveyed according to a survey and recorded plat. In 1884, a street having been laid through lot 54, the owner subdivided and recorded a plat of that part of lot 54 between lot 51 and the street, and conveyed the land in question to defendants, who took possession, and in good faith erected buildings thereon. In this survey, a line was established as the true line between lots 51 and 54, as located by the original survey, by following the lines of an old fence shown to have been treated for more than thirty years as the line of the original survey, and regarded as the division line for more than fifteen years, improvements having been made up to this fence. This line corresponded with the fences on adjoining lots, and showed a shortage in the calls and distances of the original plat. Plaintiff's subsequent resurvey started from a line assumed as one of those in the original survey without evidence that it was, and ignoring all fences and following the courses and distances marked on the plat, overlapped the line established by defendant. *Held*, that the line established by defendant must be regarded as the true one. — *Beaubien vs. Kellogg (Mich.), 37 N. W. 691.*

Under How, St., Mich., § 622, providing that county surveyors, in locating extinct interior section corners, shall re-establish them at proportional distances, as recorded in the original field notes, from the nearest known points in the original section lines east and west, north and south, from such extinct corner, a section corner on a town line should be located by lines run from the nearest known Government monuments east and west on the township line, and not by measuring from one known quarter section corner north to one south of the line, and dividing the distance. — *Hess vs. Meyer (Mich.), 41 N. W. 422.*

Under such statute the record of the survey, when made pursuant to its provisions, is receivable in evidence to show the true location of the corners, but the surveyor's work is not *prima facie* correct, and to so instruct is error. — *Idem.*

Though the statutes of Michigan authorize a board of supervisors to direct a surveyor to locate lost corners, and to return his survey, and cause it to be recorded, in which case the record shall be competent evidence to establish the corners, if he makes the survey without causing it to be recorded, it is error to allow the fact of his authority to make it to be proved in a case in which he has testified as to the location of the corners, as the jury might infer that his acts were official, and give his testimony undue weight for that reason. — *Idem.*

In this case, when formerly here, the map of the original survey was not so certified as entitled it to be received in evidence, and there was nothing in the case as then presented that showed that the premises described in the declaration came within the description of the S. E. ¼ of section 28. In the record before us this has been obviated, and the copy of the original plat of the township has been introduced, which shows according to the Government survey that the premises in question are embraced in what the Government denominated the S. E. fractional ¼ of section 28 in its patent to Lingley. It might perhaps have been more accurate to describe it as that portion of section 28 lying south of Black River; but as the fraction contained less than 160 acres, and the law required it to be sold entire, the description contained in the patent was sufficient, and is quite a customary method of description in the General Land Office. The conclusion of law which the court below arrived at — so far as it holds that under the facts of this case as now disclosed, the premises claimed are not contained in the claim embraced in the declaration — is erroneous. — *Wilson vs. Hoffman, 38 N. W. Rep. 558.*

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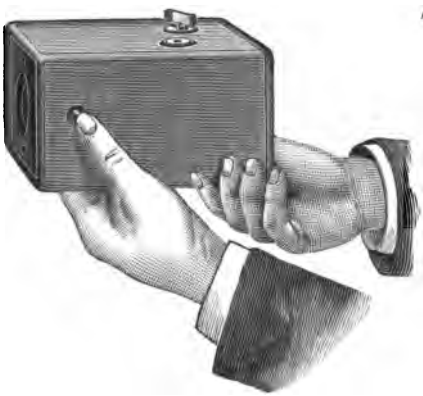

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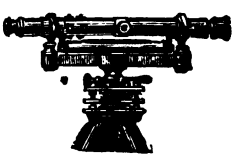

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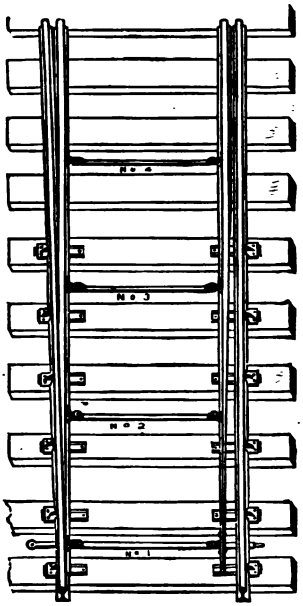

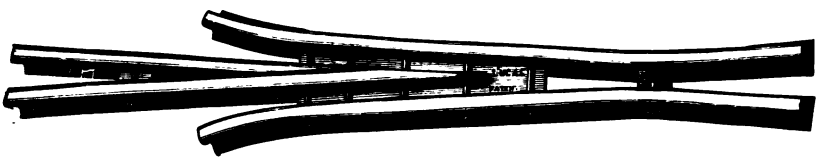

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BIOGRAPHICAL.

PROF. JOSEPH BAKER DAVIS, C. E.

PROF. DAVIS was born in Westport, Massachusetts, in 1845. His father was Ebenezer Davis, a shiprigger, whose skill in his trade was so great that it was said of him that he could plan the rigging of a large vessel so exactly that not a yard of rope would be left over. Mr. Davis's mother died when he was but a few months old, and he was taken to live during his infancy with a Quaker maiden lady, the cousin of his grandfather. This was Miss A. Baker, one of the calm, severe, prudent Quaker type, whose steady character, unswerving devotion to duty, and good deeds, had given her judgment unusual weight in the family. Her influence over Mr. Davis, acquired while he was very young, remained unchanged through her life. After he left home, he kept up a correspondence with her; and when she died, he traveled over a thousand miles to attend her funeral. In her later years, her straight figure, her calm, pure face, her white hair, and her quaint and severe Quaker garb, made her an attractive and striking personage.

Mr. Davis remained with Miss Baker at Westport until he was eight years of age, when he returned to the house of his father, who had in the meantime married again, and was living in New Bedford. His father was also of Quaker tendencies, so that in Mr. Davis's early life there were two especial and interesting features,— Quaker surroundings, and association with persons interested in marine matters. In those days, whale fishing was yet pursued with great activity, and the center of this activity was about southeastern Massachusetts. Whale fishing is a picturesque and fascinating trade, and its influence on the imagination of a young boy must always be notable. Mr. Davis's reminiscences are always full of pictures of whale fishing.

He remained in New Bedford until 1863, when his father purchased a farm a few miles out from New Bedford. From here the father used to go into the city on business, and here young Davis spent the last year with his father's family.

In 1864, he presented himself among the crowd of expectant freshmen asking admission to the University of Michigan. He was admitted, and graduated in the class of 1868, — a class which has left more of its members in the University faculty than any other class ever graduated there. In his University course, Mr. Davis's work was marked by the characteristics which have marked his life since. His sterling manliness and loyalty to his convictions gave him the thorough respect and confidence of his instructors and his classmates. His means were limited, and in addition to the work which he performed with his classmates, he had also to provide for his own subsistence. This he did in

such a way that his standing as a student did not suffer. His sterling ability, his sturdy conscientiousness in his work, and his unremitting industry, overcame all obstacles, and kept him among the first in an unusually strong class. Meantime, in all matters of college or class politics, his fellow students were never in doubt as to where Davis would stand. His strong common sense, with a tincture of Quakerism, was always his guide. His classmates well remember the thickset, strong, good-natured, and fair young man, plainly dressed, unpretentious, hearty in his bearing, and loyal to his class and to his friends. In those closely associated with him at this time, he aroused a feeling of affection which was founded on a basis of respect and confidence. There is no sentiment that is more enduring than an affection founded on such corner-stones. It can only be changed by the conviction that the corner-stones are unsafe. In this case the sentiment has remained unchanged through the quarter of a century which has elapsed since the sturdy young Davis used to occupy the seat of a student.

In the summer of 1867, and therefore while yet a student, Mr. Davis spent a season on Lake Superior, in the employ of the United States Lake Survey. It was while he was here that he laid claim, with what seriousness may be seen by what follows, to a descent from an ancient Welsh family. The chief of the party was, though a civilian, strict in the enforcement of army etiquette, and his assistants, of whom Mr. Davis was one, found themselves treated very formally at the officer's mess. The chief had the lead in conversation at the first dinner table, and he took the opportunity to enlarge on his ancestry, tracing it back that day as far as the Winthrops of Massachusetts. This continued day after day, and those who had been in his party before said it would continue all summer. At last Mr. Davis put an end to it in some such way as this: —

"May I be permitted to make a statement as to my ancestry, Mr. —— ?"

"Certainly."

"You remember that Llewellyn, prince of Wales, applied to Henry III. for protection from his own subjects?"

"Yes."

"It is said that we are descended from Llewellyn!"

The chief stood — or rather sat — aghast. He had been boasting of descent from various provincial governors; but there sat a descendant of the Welsh kings, a relation, consequently, to the reigning English family through the Tudors. The rest of the party did not dare to even smile until out of sight of the chief, but the subject of his ancestry was not discussed further during that summer.

In those days, members of the senior class in the University of Michigan finished their college work at class-day, then a month earlier than commencement. Mr. Davis did not wait during this

month to enjoy his new-found ease, but went at once into the city surveyor's office in Detroit. Office work did not, however, agree with him, and he cheerfully accepted a position which was soon after offered him on the new Kansas, Fort Scott & Gulf Railroad. He went to Kansas, and was occupied there in laying out the road until the autumn of 1869, when he returned to Michigan, and took part in running a new line of railroad near Big Rapids. At the end of this job he returned to New Bedford, and spent a part of the winter of 1869–70 with his father.

In the spring of 1870, De Volson Wood, professor of Civil Engineering at the University of Michigan, wished for assistance in his department, and could find no one more suitable than Mr. Davis. He was consequently made assistant professor at this time, and he has been a teacher of civil engineering ever since. In the following summer he acted as prospector on the Jackson, Lansing & Saginaw road. Before the college year of 1871–72 began, he was offered the professorship of civil engineering at Swarthmore College, near Philadelphia. At the end of this college year his *alma mater* required his services again, and he returned to Ann Arbor, again as assistant professor. Prof. Wood left the University at this time, and was succeeded by Prof. Greene, and the department was re-organized. Mr. Davis has retained his position from 1872 to the present day.

A large part of Mr. Davis's professional activity has been spent in teaching; in fact, with the exception of a year or so, he has been teaching ever since he graduated. During this time, a very large number have passed out from under his instruction to their professional duties. They look back with both respect and affection to their instructor, and with good reason; for, aside from those qualities of head and heart to which I have already referred, and which command these sentiments, he brought to his work as teacher a thorough knowledge of his subject, combined with a conscientiousness and painstaking which would permit no member of his class to slur over his work, or to think himself well prepared when he was not. Mr. Davis insists on as good, accurate, thorough, and honest work on the part of his pupils as he would perform himself, and he often calls their attention to what might be called the ethical side of the profession. Lives and property depend on the honesty and knowledge of the engineer and architect, and an engineer who undertakes work for which he is not competent, betrays the confidence of his employers, and may be punished by law. Thorough and conscientious work must always be done, and this wholesome lesson Mr. Davis especially impresses on his pupils.

In 1872, Mr. Davis married Miss Mary Hubbard Baldwin, daughter of Deacon J. D. Baldwin, one of Ann Arbor's most beautiful and most highly esteemed young ladies. They had been acquainted from the time that Mr. Davis was a student; and the happiness of their life together has been interrupted only by the afflic-

tions which Providence, with a wisdom that surpasses ours, has seen fit to bring on them. They have lost two boys, the eldest and the youngest, and have one living. The living son, Charles, was born in July, 1875. In 1879, they built a pretty and unique house, which they still occupy.

Prof. Davis has written but little; he has been too busy. Nor has he sought honors or employment, but has waited for them to come to him. In addition to his duties as a teacher, he has had as many professional labors as he could attend to. He was made city engineer of Ann Arbor ten or fifteen years ago, without solicitation, and while seven hundred miles away; and, through all the vicissitudes of local politics, he has retained this position. During this time, the appearance of the city has been rendered much better, and many improvements have been introduced. In 1874, he became a junior in the American Society of Civil Engineers, and he remains a junior to this day, probably the junior of the longest standing on the list. In 1883, he was made president of the Michigan Engineering Society, and held the position for three consecutive terms. He has been for a long time a consulting engineer of the Flint & Pere Marquette Railroad, and of the Toledo, Ann Arbor & Northern Railroad. He was for two years vice-president of the "Council of Engineering Societies on National Public Works."

He has interested himself especially in highway bridges, and many of the important ones in the State were built according to his designs. He has also interested himself in city waterworks, and the works of Greenville, Mich., are a standing illustration of the effectiveness, thoroughness, and economy of his plans. He takes, apparently, especial interest in that difficult, time-consuming, and exasperating duty of surveyors, — that of finding missing corners, — and to this he brings to bear an amount of tact and experience rarely found elsewhere, and a willingness to expend more labor than most surveyors are willing to put on it. The result is that with him the lost corners are always found, and with the finding of them comes the definite and authentic settlement of boundaries so necessary to the comfort of land owners.

M. W. HARRINGTON.

BUSINESS TRANSACTIONS

OF THE

MICHIGAN ENGINEERING SOCIETY

For the Year 1888–89.

MEETING OF BOARD OF DIRECTORS.

THE annual meeting of the Board of Directors was held at the Hudson House, Lansing, Oct. 10, 1889. There were present President Geo. E. Steele, Secretary F. Hodgman, and Directors Appleton and Cooley. The meeting was called to order, and the report of the Secretary was read and approved, as follows: —

REPORT OF SECRETARY.

Your Secretary would respectfully report that he has transacted the following business for the Society since the Annual Convention: A contract was made with Ihling Bros. and Everard to publish the Ninth Annual Report, 1,000 copies, for $242, cuts and extra work above that called for in the bid to be paid for by the Society. The publication was greatly delayed by various causes, but was well done, and a very satisfactory job. Ballots for new members were sent out early in the season, and the several applicants duly elected to membership. Ballots for officers were also sent out, and those returned are herewith submitted for canvassing.

Circulars relative to manner of sending out the reports, and also relative to subjects for discussion at the next Convention, were also sent to all the members, and answers received which are submitted to the Board.

The cash account of the Society stands as follows: —

On hand Jan. 17, 1888	$185.41	
Received for fees and dues to Oct. 10, 1888	247.00	
Interest on Strudwick note	6.25	
From Heller and Brightly	9.65	
From reports sold	5.00	
Total		$582.31

Paid John Eisenmann special fund Nat. Pub. Works	$ 42.00	
Secretary's salary	50.00	
Expenses of Executive Committee and Board of Directors	40.40	
Stenographer	16.00	
Returned F. E. Kirby overpayment	14.00	
Janitor at Kalamazoo	6.00	
Secretary's expenses getting out reports	15.60	
Express charges on reports and cuts	17.55	
Publishing Proceedings	208.84	
Postage and other incidental expenses	62.07	
Balance on hand Oct. 10, 1888	109.85	
Total		$582.31

The Society owes Ihling Bros. and Everard for printing Proceedings, Circulars, etc., $92.04. There is due the Society from advertisers, $40, leaving the financial standing of the Society as follows: —

Cash on hand	$109.85
Bills receivable	40.00
Total	$149.85
Bills payable	92.04
Balance	$57.81

I have recently received notice from Mr. Wright, of Bad Axe, to the effect that the property of Mr. Strudwick was to be sold on a mortgage, and asking further instruction in regard to the collection of the note in his hands. I replied to him that if Mr. Strudwick was as hard up as that, to give him the note. The Society did not care to crowd him under such circumstances.

F. HODGMAN, *Secretary.*

The Board then proceeded to canvass the ballots for officers of the Society for the ensuing year. For President, there were 58 votes cast, of which Geo. E. Steele received 36, J. B. Davis 14, and A. L. Reed 8.

For Vice-President, there were 54 votes cast, of which Joseph Ripley received 42 votes, and E. F. Guild 12.

For Secretary, 54 votes were cast for F. Hodgman.

For Treasurer, 55 votes were cast for Geo. S. Pierson.

For Directors, M. E. Cooley received 48 votes, Wm. Appleton 30, A. J. Teed 17, A. L. Drew 14, J. H. Forster 6, and E. Dennis 4.

The following persons were then declared duly elected for the term beginning Oct. 10, 1888: —

President, Geo. E. Steele.

Vice-President, Joseph Ripley.

Secretary, F. Hodgman.

Treasurer, Geo. S. Pierson.

Directors, M. E. Cooley and Wm. Appleton.

Bills of members of the Board of Directors for expenses in attending this meeting were audited and allowed as follows: —

Geo. E. Steele, $15.35; F. Hodgman, $5.00; M. E. Cooley, $3.80.

On motion of F. Hodgman, it was voted to hold the next Convention at Lansing, beginning Jan. 22, 1889.

Prof. R. C. Carpenter was appointed a committee to provide for a paper on the uses of Photography in Engineering and Surveying, and for a stereoptican exhibition in connection therewith.

The Secretary presented a list of topics for discussion at the next Convention, returned by the members of the Society in response to his circular, also a list of names of those who had consented to prepare papers. Several topics were added to the list, and names of persons selected to be invited to prepare papers on these topics. Prof. M. E. Cooley was appointed a committee to present to the Society the matter of representation in the Council of Engineering Societies. The meeting of the Board was then adjourned.

F. HODGMAN, *Secretary.*

ANNUAL CONVENTION.

THE Annual Convention was held in the Pioneer Rooms of the State Capitol, commencing Tuesday, P. M., Jan. 22, 1889.

The Convention was called to order by the President at 2 P. M., and the programme read. The Secretary's report was read and accepted, and referred to a committee consisting of J. J. Watkins, J. H. Forster, and R. C. Carpenter. The report is as follows: —

SECRETARY'S REPORT.

ARTICLE II. Section 5 of the Constitution requires the officers of the Society to report at the annual meeting all business transacted by them for the Society. As Secretary, I deem it proper to report also to the members present at the Annual Convention, adding such suggestions as the experience of the past year seems to call for.

At the close of the last Convention, the first business transacted was the preparation of the annual proceedings. Bids for the publication were received from the Kalamazoo Publishing Co., the Review & Herald Publishing Co., and Ihling Bros. and Everard. The contract was awarded to the latter company, they having made the lowest bid. Considerable time was spent in securing advertisements, a work of no little labor and trouble. I here venture the hope that in future each member of the Society will feel it both a duty and a privilege to assist the Secretary in this work, and that the feeling will be strong enough to induce action. The copy for the proceedings was furnished the publishers about the first of March. In order to avoid as far as possible all errors in printing

of the papers, revised proofs were sent to the authors for final correction. Some of the authors were slow in returning them, thereby causing much delay. Various other causes beyond my power to remedy conspired to delay the publication, which finally came to me three months behind the time agreed on. This was a source of infinite annoyance to me. I hope to avoid a recurrence of the difficulty, but my experience with the ways of the printer is not re-assuring. I held the reports a few weeks before sending them out, in order to have as many of the exchanges as possible to send with them, and make a single job of it. I regret to say that the state of the mail service was such that numerous complaints of the non-receipt of reports came to me from the members of the Society and the press. I sent copies to every member, and sent out duplicates as long as I had any left to send, but I fear there are still members minus the reports they should have. Exchanges were made with the societies of Arkansas, Indiana, Ohio, Illinois, Iowa, University of Michigan, Dominion and Provincial Land Surveyors of Canada.

No reports have been received from Missouri since 1886, and at the last account I had, they were not published.

Right here I wish to speak of the manner of sending out the reports. In Ohio, the Secretary writes me that the reports are held till all the exchanges are received, and all are sent out together at the members' expense, by express. Thus far we have sent them out at the Society's expense, but it is becoming a question of money with us. In future, we must have increased revenues or decreased expenses. Increased revenues may be had by additions to our membership, by increased advertising patronage, or by increased annual dues. To secure increased membership and increased advertising patronage, the hearty co-operation of every member of the Society is required. Heretofore not more than four or five members have done anything to assist the Secretary in securing advertising, and it is no slight burden to carry alone. As to dues, it may be said that they are very low. The Ohio Society collects its revenues by annual assessments, and they are rarely below $3.00.

Expenses may be reduced by cutting off our exchanges, publishing fewer reports, and getting them up in cheaper style. They may also be reduced by the Secretary's using less stationery and postage stamps. During the past year, aside from the circulars sent out which the members know all about, he has had more or less personal correspondence with nearly every member of the Society, and has written to every surveyor in the State, whose address he could procure, in furtherance of the objects of the Society. Much of this might have been left undone at a saving of stationery and stamps, but I believe in the long run it will pay a big interest in the investment. And right here I ask it as a personal favor that each member of the Society will furnish me with a list of every

surveyor, civil engineer, and engineering student in the State, of their acquaintance outside of the Society, with their addresses. Will you do it for the benefit of the Society?

We have received from Prof. J. B. Johnson, of St. Louis, a copy of his work on surveying, and from Geo. S. Pierson, a copy of his work on sewerage. The Secretary suggests that we should formally express our appreciation of the courtesy of these gentlemen, in donating these valuable books. The University of California has furnished its publications for the past year, in exchange for our Annual Report. We have also received the *Railroad and Engineering Journal* for the year by a similar exchange. An arrangement was made with the *Engineering News*, *American Engineer*, and *Scientific American*, by which these journals were furnished the Society the past year in exchange for short advertisements in the proceedings. These journals all rank with the best in their respective lines. I would specially mention the *Railroad and Engineering Journal* and *Engineering News*, and commend them to your good will. The latter has uniformly assisted the Society with its influence and advertising patronage, and should receive a generous response in the way of subscriptions from us.

Among our exchanges the past year was the *Technic*, published by the Engineering Society of the University of Michigan. In it we got a portrait of the first President of our Society, Prof. C. E. Greene. Many of our members would be very glad to secure a portrait of our second President, Prof. J. B. Davis, and I would suggest that measures be taken to secure it for the 1889 reports.

BALLOTS.

Letter ballots for new members and for officers were sent out in due season. None of the candidates for membership were rejected. The result of the vote for officers was duly announced by circular to every member. It strikes the Secretary that it would be well for every member to read the instructions on the letter ballot before voting, especially where there are several candidates for the same office. The ballots for officers were found in all variety of shapes. Some members even went so far as to write on the ballot for officers that they had no objections to any of the candidates, and so voted for them all. If their intentions had been carried out, we should have had two more presidents than our laws allow, to say nothing of other extras.

AMENDMENTS.

In this connection I suggest that it is probable that in the haste attending the adoption and engrossing of our Articles of Association, Constitution, and By-Laws, that they were not in all cases left in the form intended by the incorporators or desired by the later members. It is doubtful if the Board of Directors is constituted as the Society designed it should be. The By-Laws also

need a careful revision to make them harmonize with themselves, and fully express what the Society designed to adopt. If necessary, amended Articles of Association should be filed with the Secretary of State, and a committee appointed to revise the By-Laws, and submit them as revised to the Society by letter ballot.

SUBJECTS FOR PAPERS.

It would be a great assistance to the officers of the Society if every member would suggest a topic which he would like to have discussed in the Convention, and assist in getting the best man to present it. There is no danger of having too many. The more we have, the better the Directors can make good selections for a first-class programme. There are some members who can always be relied on when called on to come to the assistance of the officers in every endeavor to promote the welfare of the Society, whether to suggest topics or prepare papers, to bring in new members, or solicit advertising patronage. There are others who can equally be relied on either to make no response to an appeal for assistance, or else curtly reply that they "have no time to spend for such things." It is not necessary to express any opinion in regard to these two classes, but the Secretary has one clearly defined in his own mind, and he appeals to every member to do whatever he can to bring and keep the Michigan Engineering Society up to the best possible standing. Let us have live, active, aggressive members, without one on the list who is nothing but an absorbent. We now number 105 members, with several applications to be voted on by letter ballot. We ought to have more than twice that number, and will have, if every member does his duty.

Let us bring in the bright, zealous, active young men from the schools, and the clear-headed, brainy working-men from the profession, but do not ask a sponge or a dead-head to join the Society. Live, active men are willing to come here and exchange thought for thought and idea for idea, but they are not willing to sell the work of their brains and the fruit of their experience for two dollars a year, to be paid the Society as dues.

LAND LAWS AND DECISIONS.

I congratulate the Society on the fact that the work done by it in collecting land laws and decisions is having its effect. In evidence of it, I call attention to a recent decision of our Supreme Court on a second trial of the Wilson *vs.* Hoffman case. The doctrine was laid down in the first trial of the case, that a fractional lot cannot extend beyond a quarter line. This was re-affirmed in Keyser *vs.* Sutherland and Palmer *vs.* Dodd. The Supreme Court, of their own motion, ordered a rehearing of the Wilson *vs.* Hoffman case; and in the second trial of the case, the language of the decision clearly shows that the authorities cited and the arguments presented in the papers read before this Society, have induced the

Court to break away from an established line of precedents, and reverse their former decision in the case. All honor to them for it. We may now expect that other errors will be corrected when cases come properly before them for consideration.

We now have no committee on this or any other branch of our work. I recently wrote to the great law publishing firm of West & Co., St. Paul, who publish the *Northwestern* and other reporters, asking them if they would furnish us with sheets from their publications containing reports of cases of interest to us, for binding with our annual reports, and also if they could themselves, at the end of each year, furnish us with a volume containing that class of cases decided during the year, and if so, at what cost. They replied that for reasons which they gave, it was not practicable for them to do either, but that they could put us in a way to get what we desired. They publish a monthly Digest, containing the syllabi of all decisions reported for the month, throughout the United States. From this we could cull whatever we wanted. If any case seemed of sufficient importance to warrant it, we could get the full text of the decision for twenty-five cents. We can have the privilege of publishing in our proceedings by giving proper credit. The Digest, of which I have samples, will cost us $5.00 per year; and I favor subscribing for it, as a most valuable addition to our means of information.

REPORT OF SPECIAL COMMITTEE IN SECRETARY'S REPORT.

The committee to whom it was referred, reported as follows, and the committee's report was accepted and adopted, except the parts relating to changes in the Constitution and By-Laws, which could not be adopted at this meeting.

To the Members of the Michigan Engineering Society:—

GENTLEMEN: Your committee to whom was referred that portion of the Secretary's report recommending some changes in our Articles of Association and By-Laws, desire to report it advisable to change the reading of Article III. of Articles of Association, so as to read as follows: —

"The officers of this Association shall be one President, one Vice-President, one Secretary, and one Treasurer, which last two named offices *may* be filled by one person, and a Board of five Directors, two of whom shall be the President and the Secretary.

"The annual meeting of this Association shall be held on the second Wednesday in October, at Lansing."

That Article III. of the By-Laws be amended by striking out the word "membership," and inserting after the word "fee" the words "of three dollars."

That Article V. be amended to read as follows: —

"On being elected, the applicant shall sign the Constitution and By-Laws (unless when for removal and having signed a copy of the

same transmitted to him by the Secretary, the Secretary may enter his name to the list of members as having signed), and shall pay into the treasury an initiation fee of three dollars, and when admitted as a senior member the further sum of two dollars, after which payment or payments, he shall receive a certificate of membership. If said initiation be not paid within thirty days from notice of election, said election shall be void."

That Article VI. be amended to read: —

"Every person admitted into membership of this Society shall be liable for the payment of his assessments so long as the Society shall retain his membership; but after payment of all dues, at his request he may be released from his connection by a vote of the Society at its annual Convention. Any member neglecting or refusing to pay any assessment for three months after due notice by mail, may at the option of the Society be declared as having forfeited his membership.

In reference to sending out reports, we would recommend that the reports of our proceedings be forwarded by mail to each member not in arrears for dues or assessments, and that our exchange reports be forwarded by express at the expense of the individual members.

That it shall be the Secretary's duty in behalf of the Society to courteously acknowledge the receipt of all books, maps, and other matter donated to the Society, and any omission that may have occurred in suitable recognition be corrected at his earliest convenience.

It is also recommended that this Society procure the "American Digest," and that the Secretary be the Committee to procure such Digest and make selections therefrom touching all important matter necessary for our vocation to be printed in our report.

It is recommended that our President address a letter to our last past President, soliciting him to furnish the Secretary with a likeness of himself, to be included in our next annual report.

Respectfully submitted,

JOHN I. WATKINS,
JOHN H. FORSTER,
R. C. CARPENTER,
} *Committee.*

REPORT OF SPECIAL COMMITTEE ON COUNCIL OF ENGINEERING SOCIETIES.

Prof. M. E. Cooley, who was appointed by the Board of Directors a committee to consider the relation of this Society to the Council of Engineering Societies, reported the work being done by the Council as in a favorable condition, with a fair prospect of the attainment of its chief object, the establishment of a National Board of Public Works, and recommending that the Society place itself in a position to co-operate with the Council. The report was accepted, and it was voted that a committee be appointed, consisting of Prof. J. B. Davis as Chairman, and the Board of

Directors to take such action relative to the work of the Council of Engineering Societies as they may deem for the best interest of the Michigan Engineering Society. The committee furnishes for the information of the Society details of the present condition of the work of the Council of Engineering Societies from which the following items are condensed.

The House Committee on expenditures in the War Department on the 19th of February, 1889, reported to the House a bill which provides for the establishment of a Bureau under the War Department to be known as the Bureau of Harbors and Water-Ways, to be officered by a corps of United States Civil Engineers. The organization, duties, pay, etc., of this corps is provided for in the bill, and all engineering works of a civil character carried on by the Government are placed under their direction. The bill was carefully drawn after a very full discussion of the various points, and meets the views of eminent civil engineers who have been interested in the matter. The following extracts from the report of the House Committee partially presents their views in regard to the proposed change: —

"In the opinion of the committee, the time has come to inaugurate a definite policy in regard to national public works, and to provide a specific agency for its execution. The sense of the people and of Congress has shown a steady growth for twenty years in favor of the development of harbors and water-ways. During this time grave objections have been urged against legislative and administrative methods, and these objections have gathered force with each passing year, until the enactment of a river and harbor bill is uncertain and occasional, instead of being regular and the best approved legislation, as it should be.

"In legislation, it is charged that Congress is not appropriating in harmony with any well-conceived general plan or system; that each work is largely considered as a detached or individual work, without special regard to any other or to any collection or group of works as a whole; that appropriations are uncertain and inadequate for economical results, and often for any results at all; and that the largest and most important national works fail to receive that attention which is indispensable if they are ever to be completed.

"In administration, various objections are urged which are largely incidental to the necessary method of organization of a military body, and that are not adapted to a strictly civil work and function. Upon some important public works, Congress has thought it judicious to provide irregular mixed commissions. A necessary and the larger part of the technical force is without proper recognition, tenure of position, or hope of advancement, resulting in constant change in *personnel* as some experience is acquired. The military system does not readily adapt itself to the best civil practice, nor is it desirable that it should, if the corps is

to remain a part of the army. It is unnecessary to more than refer to this phase of the question, as the passage of the bill is urged largely on other grounds.

"The truth of these allegations, to a greater or less degree, is acknowledged by every one. They can be indefinitely multiplied and expanded, and have been ably presented to your committee. Great good would come by changing the legislative practice, likewise, by a specific adaptation of the administrative organization to its work. These changes should, however, be complementary for the best result. What this result should be, may be best indicated by the history of recent appropriations.

"Since 1880 we have had appropriations practically every other year, uncertain in amount, uncertain as to passage, and, in detail, an uncertain fraction of the estimate for each work. Every one will admit that the results obtained have been in many cases very meager. Every one will admit that, had the same total been appropriated in regular sums year by year, far more would have been accomplished. It will probably be conceded that could the money be applied in the best manner in accordance with some rational system, far greater results could be had. In other words, we fall far short of accomplishing what we should do under a proper system.

"Mere changes in the methods of making appropriations, or in the administrative system, or both, will not be sufficient. The evil is fundamental, and requires a radical change. Congress, for some reason, has taken upon itself functions which in other countries, more advanced in these works than ours, are performed by a board of public works, a board composed of technical experts who have made the possibilities and the needs of their country a life study.

"In carrying the law into effect, your committee does not see that the progress of public works need be hindered or stopped. The change can be brought about in such a manner as to produce no break in the continuity of operations.

"When we consider the enormous total required to complete the works now projected, and the inadequacy of the appropriations when compared to the annual estimates, we fully believe that under the system proposed, the completion of these works will be greatly hastened, at less expense, and on plans better considered in reference to the needs of the country and the future possibilities of a water-way system."

The following extracts from a letter accompanying Prof. Cooley's report shows further the condition of the work and the relation of the Michigan Engineering Society to it.

ANN ARBOR, Jan. 22, 1889.

Prof. M. E. Cooley:—

MY DEAR SIR: In answer to your inquiry concerning the Council of Engineering Societies, organized three years ago for the organization of national public works in the United States, and

the relations of the Michigan Engineering Society in regard thereto, I can offer you a few facts and suggestions.

The Michigan Engineering Society, for a time, took an active part in perfecting the organization of the Engineering Societies. Our Society was honored by its part in the matter, and your humble servant, because of being its representative, was placed in responsible and honorable positions in that work. At our Grand Rapids Convention, I think it was, our Society discharged its committee, and severed its connection with the movement, at a time when its aid was much needed and when results were being reached. I am sure our Society ought to take part in this national effort of our profession to do what it can to improve this branch of service, and to make it a civil service of efficiency. I hope our associates will enter again upon this work with earnestness and devotion. I believe the day will come when they will not want to be left out. Michigan cannot afford to be left out. About 10 per cent of the River and Harbor money is spent on the lakes. Michigan gets much of, if not the most of, that 10 per cent.

This State needs well-made and well-expended appropriations if any State does. With a coast exceeding the whole Atlantic east front, and with a coast-wise commerce exceeding that of the whole Atlantic coast, I believe I may be pardoned for thinking that our State has an interest in every improvement that can be made in the method of our public works. When one reflects that our Sault Ste. Marie Ship Canal (the first in the United States) carries a tonnage to-day equal to, if not greater than, does the Suez Ship Canal that is justly regarded as a highway of the nations, it is conceivable, I think, that one might consistently believe that Michigan has interests at stake in the national conduct of public works for bettering navigation. And I do n't believe our engineers are careless of these interests. They simply do n't realize the case. Now the case is just this : —

1. We have no system of public works.
2. We never did have.
3. We pride ourselves on being free people, governing ourselves, administering our own affairs.
4. Internal improvements are civil public works, not military.
5. What money is spent in this line at present is disbursed by the army.
6. Germany, France, Italy, and Great Britain have such work done by civilians. In fact, the more military the nation, the more perfectly is this work organized on a civil basis.
7. Should our public works be civil or military in character in comparison ?
8. These great nations have a system ; we do not.
9. The civil engineers of this country, from the Atlantic to the Pacific, and from Lake Superior to the Gulf of Mexico, have

organized to do what can be done to get a system, and an edequate one.

10. Much has been done. The work is in good shape, thanks to the President and his associates, of which I do not hesitate to speak, as I have held no official connection with them for about two years. What has been done you can see from the printed matter herewith.

11. This work is to go on, I believe, to a successful issue.

12. There is opposition; but not on the principle. There can be none. The opposition, so far as it is manifest to me, is specious, local, or selfish, or tries to be, not knowing where true self-interest lies.

13. This movement is past the polyp, jelly-fish stage. It walks. It has friends. It has enemies. It is sound and healthy.

14. It requires men, money, thought, study, effort, and counsel to carry it on.

I cannot condense the case into a sentence beyond saying, We, as a nation, have *drifted* in this matter; there are defects and abuses in consequence; it is time to man the sails, take the helm, and steer.

I wish the Michigan Engineering Society might feel it a duty to bear a hand.

Cordially yours, and theirs,

J. B. DAVIS.

APPLICATION FOR MEMBERSHIP.

The following applications for membership were passed upon by the Board of Directors, and approved for Senior Members: —

Brown, F. H., Surveyor, Sault Ste. Marie, Mich.; Baldwin, Willis, Surveyor, Monroe, Mich.; Coryell, R. J., Surveyor, Jonesville, Mich.; Campau, Thomas, Surveyor, Detroit, Mich.; Cox, George, Civil Engineer, Sault Ste. Marie, Mich.; Davis, Geo. L., Civil Engineer, Cadillac, Mich.; Davis, L. M., Civil Engineer, Gladstone, Mich.; Douglass, Benj., Civil Engineer, Detroit, Mich.; French, Edgar, Civil Engineer, Battle Creek, Mich.; Gifford, Jas. M., Surveyor, Duck Lake, Mich.; Hayes, Eli L., Surveyor and Map Publisher, Reed City, Mich.; Jones, E. H., Surveyor, Greenville, Mich.; Kedzie, Frank S., Chemist, Agricultural College, Lansing, Mich.; Merritt, R. B., Surveyor, Battle Creek, Mich.; Mc Loughlin, John, Civil Engineer, Detroit, Mich.; Mahon, Wm. L., Mechanical Engineer, Detroit, Mich.; Pelham, Fred B., Civil Engineer, Detroit, Mich.; Roehm, George E., Civil Engineer, Detroit, Mich.; Smith, Stewart K., Civil Engineer, Somerset, Mich.; Shenehon, Frank C., Civil Engineer, Sault Ste. Marie, Mich.; Sowter, I. G., Mechanical Engineer, Detroit, Mich.; Todd, O. H., Surveyor, Nottawa, Mich.; Van Culebroeck, A., Boiler Maker, Lansing, Mich.

NOMINATIONS FOR OFFICERS.

The following names were placed in nomination for officers of the Society for the ensuing year, to be voted on by letter ballot: —

For President: R. C. Carpenter, A. L. Reed, Joseph Ripley, I. H. Leavenworth.

For Vice-President: J. H. Forster, John J. Granville, John J. Watkins.

For Secretary and Treasurer: F. Hodgman.

For Directors: Geo. E. Steele, A. J. Teed, M. E. Cooley, Frank F. Rogers, Chas. E. Greene, Seth N. Beden.

On motion of F. Hodgman, it was voted that the Board of Directors be authorized and directed to file in the office of the Secretary of State, Amendments to the third Article of the Articles of Association, providing that the Board of Directors shall consist of five members, two of whom shall be the President and Secretary, and that the remaining three members shall hold office for the term of three years each, one member to be elected each year, except that at the next election one Director shall be elected for one year, one for two years, and one for three years.

On motion of Prof. Carpenter, it was voted to pay the Secretary $50 for the past year's services.

Mr. McLoughlin, of the committee to whom was referred the President's Address, made a report commending the address, and recommending that the professors in our State institutions of learning be requested to cause to be furnished to the public, through the press, such matters of interest to engineers as may be brought out by their investigations; and further recommending, that committees of one member each be appointed to consider and bring before the Society matters of interest on the following topics: —

1. Questions of practice.
2. Court decisions.
3. Photography.
4. Standard specifications for block pavement.
5. Standard specifications for pipe sewers.

The report was adopted.

On the suggestion of Prof. Cooley, it was decided informally to defray the expense of the portrait of Prof. Davis, by contributions from the members.

Detroit was chosen as the place for the next meeting.

The Convention was closed with a fine exhibition of stereoptican views by Profs. Frank S. Kedzie and R. C. Carpenter, of the Agricultural College.

ATTENTION!

THE Secretary desires to call attention to the advertising columns of the Annual. The firms there represented are all worthy of our patronage, and should receive it. In view of the progress of photography as applied to engineering science, the advertisements in that line are of special interest. The portrait of Prof. Davis furnished the Society with this number of the Annual, is from the Eastman Dry Plate and Film Company, whose advertisement will be found in these columns.

ERRATUM.

IN the "Proceedings of the Michigan Engineering Society for 1888," on page 139, twelfth and thirteenth lines, for "above zero in ascending a grade line, or below zero in descending it," read "BELOW zero in ascending a grade line, or ABOVE zero in descending it."

OFFICERS FOR 1889.

President — GEORGE E. STEELE, Traverse City, Mich.

Vice-President — JOSEPH RIPLEY, Detroit, Mich.

Secretary — FRANCIS HODGMAN, Climax, Mich.

Treasurer — GEORGE S. PIERSON, Kalamazoo, Mich.

Directors.— M. E. COOLEY, Ann Arbor, Mich.; WM. APPLETON, Lansing, Mich.; and the President, Secretary, and Treasurer, *ex officio*.

LIST OF MEMBERS.

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BAILEY, M. H., Surveyor, Dimondale, Eaton Co., Mich.

BRADT, J. C., Surveyor, Marcellus, Cass Co., Mich.

BALDWIN, WILLIS, Surveyor, Monroe, Monroe Co., Mich.

BARRINGTON, EDWARD, Civil Engineer, West Washington, D. C.

BAMBER, HERBERT, U. S. Ass't. Engineer, Post-Office Bdg., Philadelphia, Pa.

BECKMANN, L., Manufacturer Surveying Instruments, Toledo, Ohio.

BEDEN, SETH N., Surveyor and Civil Engineer, Pine Run, Genesee Co., Mich.

BELLOWS, C. F. R., Prof. Math., Mich. State Normal School, Ypsilanti, Washtenaw Co., Mich.

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CAMPAU, THOMAS, Surveyor, Detroit, Wayne Co., Mich.

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CARPENTER, L. G., Prof. Eng. State Ag'l. College, Fort Collins, Colo.

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DAVIS, L. M., Civil Engineer, Gladstone, Mich.

DAVIS, J. B., Asst. Prof. Civil Eng., Univ. of Mich., Ann Arbor, Washtenaw Co., Mich.

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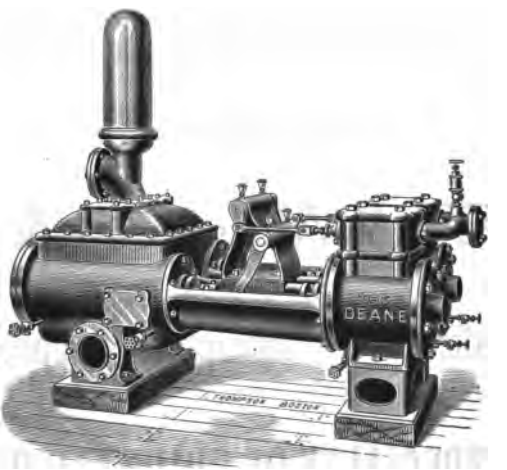

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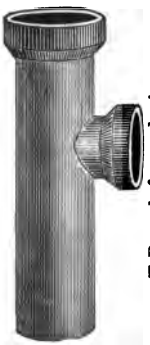

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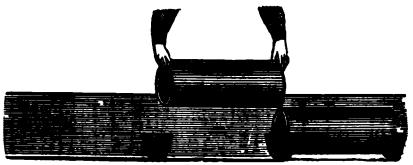

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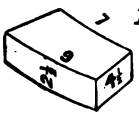

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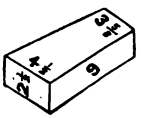

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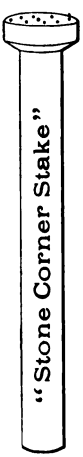

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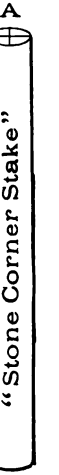

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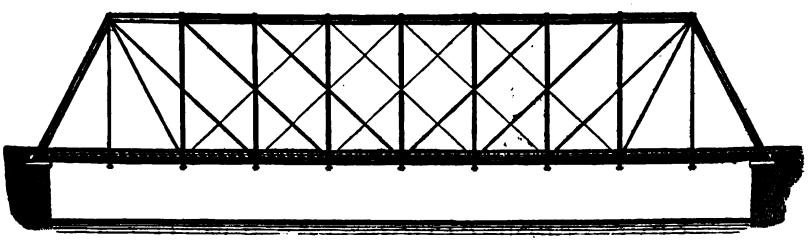

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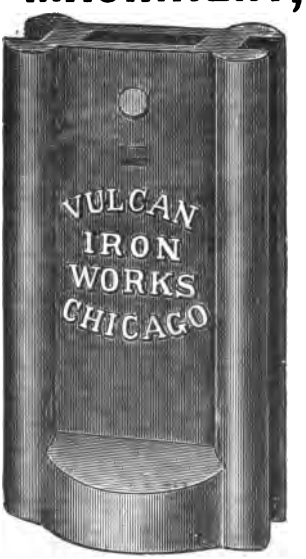

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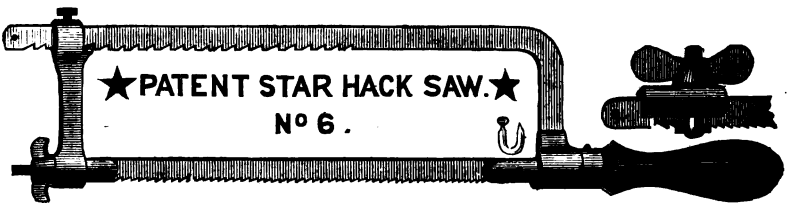

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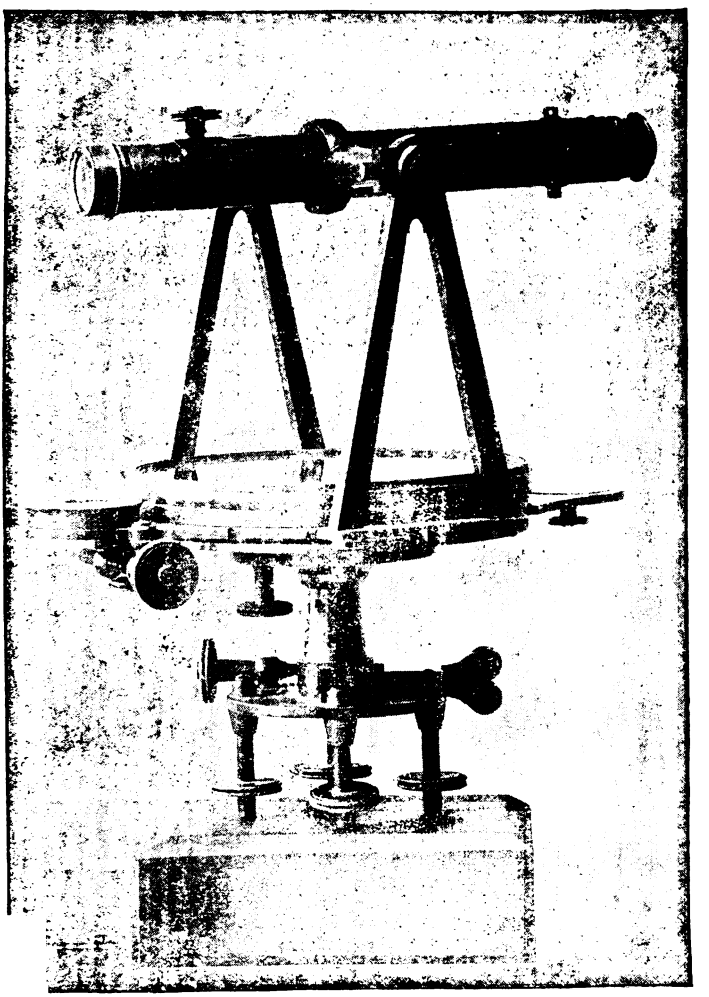

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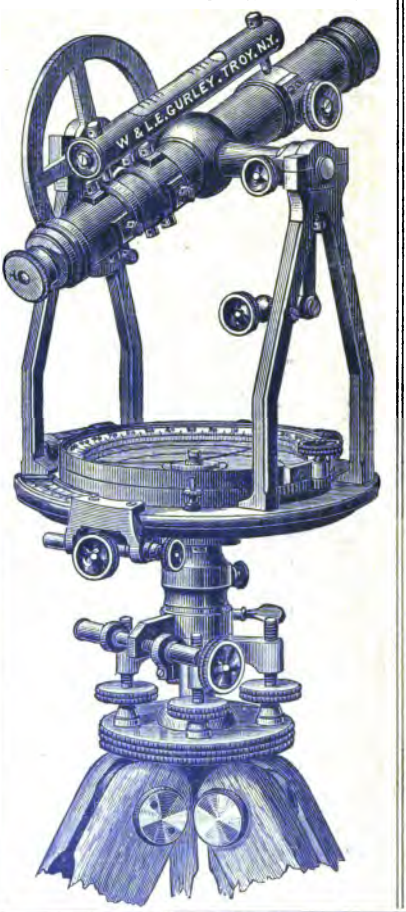

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CONTAINING THE

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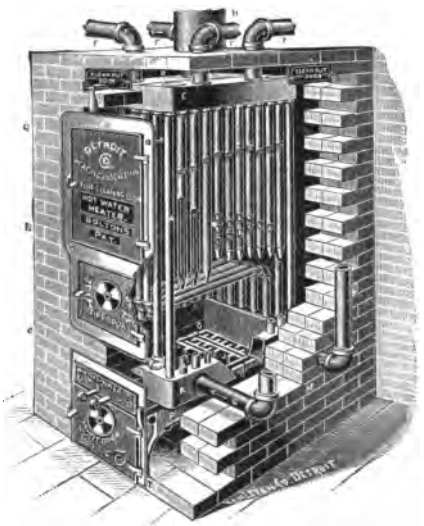

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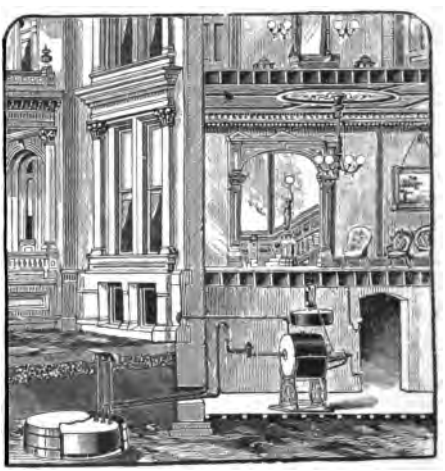

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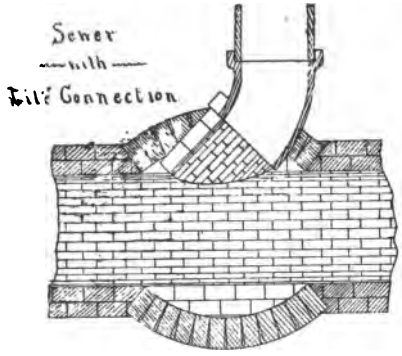
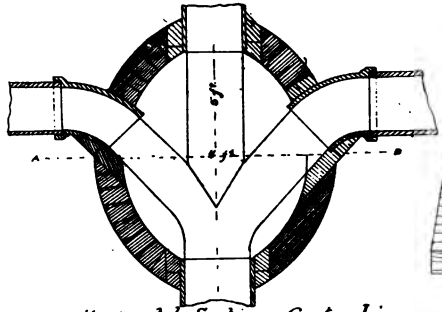
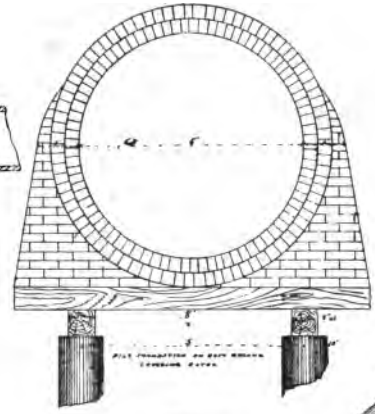


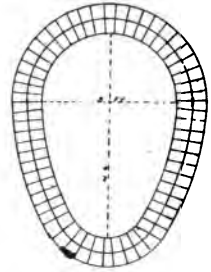
Horizontal Section on Center Line of Sewer

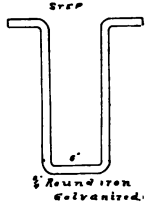
MANHOLE "B"

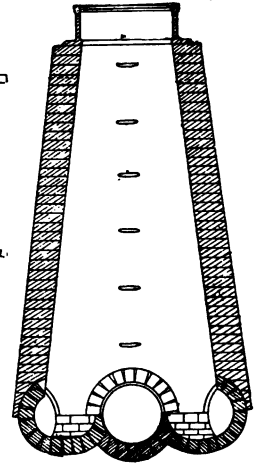


Horizontal Section on Center Line



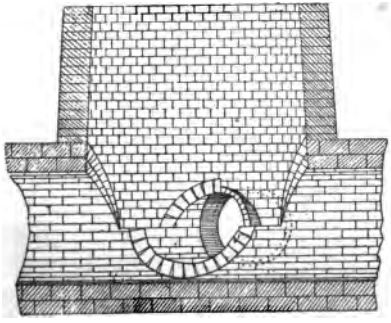




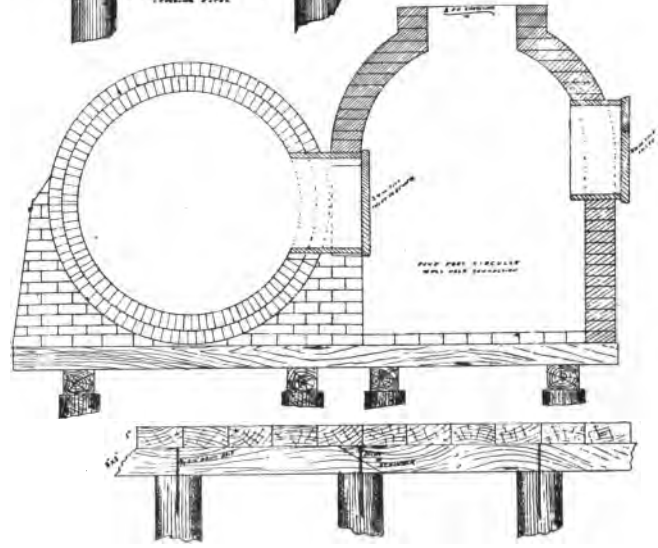


Vertical Section on Line 'A B'

MANHOLE "A"



SIDE ELEVATION



Recent Sewer Construction
WEST BAY CITY MICH.

MICHIGAN ENGINEERING SOCIETY.

Papers and Discussions at the Eleventh Annual Convention, held at Detroit, January 21-23, 1890.

SEWERAGE OF WEST BAY CITY.

DURING the years 1888–89, a system of sewers was designed and constructed by the Board of Public Works, a short description of the same being attached.

The outlet is into the Saginaw River, and lying back from the river is a low, marshy tract of ground running parallel to and about two thousand feet from it. Between this bayou and the river is a sand ridge upon which the business part of the town stands. The principal object sought after was to drain the bayou and in connection therewith to establish a system that would meet the requirements of drainage for all time to come. The Board of Public Works divided the city into districts and made plans for a main sewer.

The main sewer is constructed of double rings of brick, and all district and lateral sewers of socket tile. The outlet is a box 5x5 feet inside, made of 6x6 inch Norway drift, bolted together with a 4 inch top and bottom spiked to the sides. The box is about 175 feet long, and at the lower end the bottom is 18 inches under ordinary water level. When solid ground was found, the brick-work was started and excavations made, by the use of pumps in keeping out the water, as the bottom was below the surface of the river, and the soil sharp sand. A wood invert was provided to shape the sides and bottom of the trench, and the brick laid thereon for a distance of about 600 feet, when clay was found of sufficient hardness to be shaped by lines and templets to receive the brick. The sewer from the river to the bayou is 5 feet inside, round, a distance of 3000 feet, built on a grade of 1 foot in 2000 feet. In this distance there are two curves of 80 foot radius and there

is practically no change in the velocity around them. At the bayou there was no bottom solid enough to build on, and piles were driven 24 feet, sawed off and timbers laid thereon for a foundation. After intersecting the bayou, the size and shape was changed from round to egg shape, 36x54 inches, and this size continued on a grade of 1 foot in 1000 a distance of 2900 feet, where, after making another angle and crossing the bayou a second time, the size was again reduced to 28x42 inches which size was continued 2500 feet. The average depth of the large sized sewer was 19 feet; in some places being as deep as 23 feet and in sand. Manholes are built at intervals of about 300 feet, or at every crossing.

The main district sewers will be 18 inches in diameter with 12 inch laterals and 6 inch house connections, and will be on a grade of from 1 foot to 3 in 100, which I think will be sufficient to be self-cleansing.

The brick were hard burned and tested for lime, etc., by being immersed in water until thoroughly wet, and then laid by experienced men with Buffalo cement and sharp sand in proportion of 1 to 2.

The entire cost of main sewer was about $50,000.00, for which bonds of the city were issued.

H. C. THOMPSON,
City Engineer, in charge of Sewer Construction.

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AND MUNICIPAL PUBLIC WORKS.

H. C. THOMPSON,

Civil Engineer and Surveyor. County Drain Commissioner.

WEST BAY CITY, MICHIGAN.

PERSONAL REMINISCENCES OF RANDOLPH NUTTING.

SOMETHING like twenty years ago, the Highway Commissioner of Pavilion, Kalamazoo County, Michigan, came to me to get me to survey the line of a highway that they wished to lay out in that township. The man said:—

"We have been in the habit of employing Randolph Nutting to do our surveying in that part of the county, and I have had him at work on this job for a week, without accomplishing anything. I can't stand it any longer and I wish you would go and run out the line."

"What is the matter with it?"

"Oh, nothing, only old Randolph has got cracked on religion. He always was a little off in the upper story, and now he is worse than ever. I got him out to run the line, and the first thing he did was to get down on his knees in the dirt and pray. Then he measured his chain to see if that was right and then he prayed again."

"What did he measure his chain with?"

"Oh, with a two foot-square. Then he went to get a corner to work from, and he spent the whole day digging and praying and puttering around that corner. Next day he began to run the line, but he had not gone more than forty rods when he had to get down and pray again and then go back and measure it over. Then he was dissatisfied with the starting point, and went back and fussed and dug and prayed over that, and so he kept going for a week."

I found it about an hour's work when I got there. It was not the first time I had heard of the eccentric surveyor, Randolph Nutting, or "Old Randolph" as he was more familiarly called, although I had never seen him.

A winter or two after that, I was employed to survey a section in a thinly settled tract in the southeast part of the county. It was nearly all heavily timbered with beech and maple, and cut up with long stretches of black ash, willow and tamarack swamp. There was a light snow on the ground, and as we were passing through a piece of low land, I noticed a track in the snow leading up to a large, fallen, hollow sycamore tree. Thinking it some hunter's track, I followed it to the tree and looking into the hollow at the butt, I saw a rude old surveyor's compass, Jacob's staff and chain hid away in it.

"Hello," said one of the men, who was with me, "That is old Randolph's kit. He has been at work all alone over in

the big willow swamp, running out a section line. The willows are terrible thick over there, and he has been at it for more than a week, cutting lines through with his hatchet and setting stakes. He has got the brush trimmed out pretty near a rod wide for a mile, and stakes set up as high as his head every ten rods."

"Who is he at work for?"

"Oh, he is doing it on his own hook. He thinks they ought to have the line run out, and likely he is out of money, and when he gets it done he will call on them for pay."

"But will they pay him?"

"Oh, yes, the old fellow has got to be taken care of somehow, and you can't give him anything. He won't take it. He only charges ten shillings a day and we may as well give it to him that way as any other. Besides, he is terrible accurate. He won't set a corner nor tell you anything about it till he knows it is right to a sixteenth of an inch. When he measures a line everything has got to be just so. It has got to be measured straight, and the chain has to be perfectly level. He always measures a line twice over, and if it does not come out alike to a quarter of an inch he will keep measuring it over till it does."

"Where does he stay?"

"Oh, he has got a hut over in the edge of a swamp about three miles from here that he makes a home of, but he goes all around the country. Sometimes he sleeps in barns or in hollow logs in the woods. Most any of us will keep him over night, or give him a meal, if he would take it, but as I said, you can't give him anything. If he has any money he will come to the house for a meal or lodging and he always pays just ten cents for a meal, no more and no less. If he is out of money and work, he will lay out around the stacks, or in a hollow log, till he can get a job. He will go to running a man's line, where he thinks it ought to be done, whether they hire him or not. Most of us take him in and board him while he is at it, and maybe furnish him some help. He generally manages to board out his wages before he gets through with a job."

"Has not he any family or friends?"

"Only some sisters out near Vicksburg, and he won't live with them, or take anything from them without pay, anymore than from anybody else. They say he was disappointed in love when a young man, and has been cracked ever since.

"I noticed his tools were not in very good order. I should not think he could work with them."

"Oh, well, there are some of the boys that are always playing some trick on him, and they have just about spoiled his compass several times. He hardly ever uses a chain. He takes a piece of light wire four rods long, and puts handles on, and uses that to measure with. It is so light he can straighten it right out, and it is a good deal handier than a chain. It comes handy too, when he is setting his 'rock-bounds.'"

"What are they?"

"Oh that is the way he fixes the corners. When he sets a corner that he is satisfied with, he sets out four pins quite a little way from the corner, so that when the wire is drawn straight each way between the pins it will cross exactly at the center. Then he digs a big hole from four to six feet deep, and gets the biggest stone he can find and puts into it. I have got one at one of my corners that is as big as a hogs-head. It took three yoke of oxen to haul it in a stone-boat to the corner. When he gets the stone into the hole he fills in all solid around it and then drills a hole into it six inches deep and big enough to set his Jacob's staff in. That is what he calls 'rock-bounds.'"

"Has he put in many such?"

"Quite a good many. He would have put in a good many more, but he never will put in a rock-bound unless he knows the corner is exactly right, and besides a good many folks don't want to bother with him, or to haul the stones for the corner. Of course he can't haul them himself, and if he cannot get the interested parties to haul them, he generally makes some private mark so he can tell where the corner is and lets the corner go without anything."

Soon after this conversation, some one set fire to his cabin, one cold night in the winter, just for the fun of seeing what "Old Randolph" would do. The result was that the cabin with all his notes and other contents were destroyed, and "Old Randolph" narrowly escaped with his life. After that, he laid out for a time in the woods, as I was told, until his feet were so badly frozen that he could not take care of himself, and others had to care for him. He was provided for, I knew not how, until he could get around again, when the supervisor of the town where he made it his home "put up a job on him" to get him into the poor-house. I think this was in the winter of 1869 and 70. A resolution was passed by the Board of Supervisors appointing Randolph Nutting County Civil Engineer, for the purpose of planting "rock-bounds" around the county farm. He was to receive ten shillings a day for his services,

while actually at work, and was to be boarded at the county house for ten shillings a week till the work was done. He was to have whatever assistance he required from the inmates of the county house in making the surveys. I was at the time serving my second term as County Surveyor of Kalamazoo county, and had my office at Galesburg, near which village the county farm is situated. I had never met "Old Randolph," but was posted by the supervisors as to what was being done.

One cold, blustery day in January, I sat in my office writing up my records, beside a warm and crackling fire. Outside the snow was falling thick and fast, whirling around corners and piling up in great heaps across the streets. Suddenly my office door opened and a gust of flying snow-flakes burst into the room, followed by what at first sight might have been taken for Santa Claus himself. When the door was shut, and the snow-flakes melted, I saw before me a man apparently between 45 and 50 years of age, about 5 feet, 6 inches in hight, very strongly built, as if possessing great physical power. He was meanly clad in a ragged coat, pants, and shirt without a vest. Coat and pants were in tatters; the pants were without suspenders and held up by a cord around the waist. The coat was short of buttons, and was held together by a straw rope bound around him. He had no boots. His feet were wound about with rags, and over them he wore a heavy pair of woolen stockings, into which the bottoms of the trousers legs were tucked. He handed me a paper and made known the business which brought him. The paper was signed by the chairman of the Board of Supervisors and by the County Clerk, and set forth over the great seal of the county that the bearer, Randolph Nutting, had been duly appointed County Civil Engineer to place "rock-bounds" about the county farm. He came to me for field notes and information relative to corners in that vicinity. I gave him such information as I had, and allowed him free access to the field notes to copy whatever he desired. When he had got what he wanted, he drew his chair up beside the fire, enjoying the cosy warmth, and entered into conversation. I remember now but little that he said, and only carry a vivid impression that much of it showed evidence of deep thought, and careful though not extensive reading. There was much of originality and power mingled with wild wanderings, that showed an unbalanced mind. He was certainly a better land surveyor than I was, or anyone else that I knew. He was much impressed with the idea of having been appointed County

Civil Engineer, and returned to it again and again. Once, after sitting for several minutes silent and thoughtful, he broke forth, "Now then," he said, "to study. I have been thinking over our respective offices and position, and in one respect I think they are very much like those of members of Congress. A representative in Congress is elected by the votes of the people in his district. A senator is elected by the votes of the members of the State Legislature. You are the County Surveyor. You was elected by the votes of the people of the county. I am the County Civil Engineer. I was appointed by the Board of Supervisors, and have my commission as you see under the seal of the county. Now I think my office is about as much above yours as a senator is above a representative."

He went his way. The time was not propitious for setting "rock-bounds." The ground was frozen, the weather inclement, and the paupers poor help for such a surveyor as old Randolph. I think he got an inkling of the scheme that had been worked, or suspected it, for he staid at the county house but a short time and then returned to his old haunts. I saw him occasionally after that. He put up a new cabin in which he dwelt, and continued to do surveying as he had done before. His religious fervor passed away and he was inclined to be disputatious on religious matters. He attended church and would interrupt the minister in the midst of the sermon to argue a point with him, till they were obliged to "fire him out." One day some of the neighbors, not having seen him stirring about his cabin for a day or two, went to look after him, and found him tossing about in a delirium, severely bruised and hurt, and a hole through the roof of his cabin. A physician was immediately called, but he never recovered enough to tell what hurt him. He lingered in great agony for a few days and died. I tried to get copies of the field notes made by him, but there was nothing left of any value. The accumulations of years had been burned with his cabin as before mentioned. "Old Randolph" is gone, but his memory as an honest, eccentric man, and a thoroughly accurate land surveyor, is fresh and green among his old neighbors, and the "rock-bounds" he planted will perpetuate his good works when we shall all of us have been forgotten.

F. HODGMAN.

THE GRADIENTER.

WHEN we find ourselves in possession of a good machine, one capable of a great many kinds of work, it is desirable to know something of its anatomy or parts, particularly of any weak points in it.

In our *Gradienter*, which is of great and growing usefulness, is a fallacy not generally known to engineers.

The theory of this machine—or attachment to our transits —is *that the variation in the angle of elevation of the telescope, varies strictly with the number of revolutions of the tangent screw.*

So far as the *sine*, the *chord*, the *arc*, and the *tangent* of an angle may be regarded as equal, the above law may be regarded as true ; but above $2\frac{1}{2}$ to 3° this assumption will lead us into error, as a few examples will illustrate.

"But," says the objector, "is not the triangle made by the 'distance,' and the 'reading' of the rod, as base and perpendicular, *similar* to that made by the length of the 'lever,' and the length of the 'screw,' as base and perpendicular?"

The reply is that these two triangles are always rigorously similar- and therefore proportional. But it does not follow that the successive increments of the angle of elevation of the telescope—and therefore that the successive increments of the reading of the rod, for each turn of the screw are equal. And here is the fallacy that I wish to point out.

These successive increments *are not equal*, as the following consideration will show.

With equal consecutive increments of the arc of an angle, the tangent is increased by an *increasing* increment. But in this case, the tangent is increased by a uniform increment; whence the arc, and consequently the reading of the rod, is increased by a *decreasing* increment.

The cause of the falling off of the rate of the increment of the angle of elevation of the telescope, is seen from another consideration. The screw, working in the direction of the tangent of the arc, which the lever actuating the telescope describes, the point of application of the screw slides over the external part of the secant of the angle of elevation, of the telescope, thereby *increasing the radius*, and as a consequence *diminishing* the increments due to the successive turns of the tangent screw, and as a consequence *diminishing* the consecutive increments of the reading of the rod,—*so that these readings do not vary in proportion to the number of turns given to the tangent screw*,—which is the popular theory of the *Gradienter*.

This erroneous principle always results in giving distances *too small*, except those determined with angles under about 3°, as before mentioned.

A few examples will illustrate. We will take an angle of elevation greater than usual, in order to show the error more conspicuously.

Suppose we give to the screw of the Gradienter scale, 30 revolutions,—two revolutions corresponding to 1 foot at the distance of 100 feet.

Then the theoretic angle due to the elevation of the telescope, would be 30 times the angle due to one revolution, or 8°, 35′, 50″. And the theoretic reading of the rod would be 15 feet.

The arc of this angle, to radius, 100 feet, would be 15,050 feet.

Regarding this amount of arc as so much tangent (as we must since it is measured in the direction of the tangent), we find the corresponding angle of the elevation of the telescope to be 8°, 32′,—thus showing a falling off of 3′, 50″ from the estimated elevation of the telescope,—and a consequent falling off of .115 feet in the reading of the rod,—and as a further consequence, a falling off of 11.5 feet per 100,—or 115 feet falling off per 1000, in the distance.

In the same manner, 22 revolutions of the screw would show a falling off of 1′, 35″ in the theoretic angle of elevation of the telescope, and a corresponding shortage of 4.6 feet per 100, or 46 feet per 1000, in the distance.

And 15 revolutions would show a shortage of 30″ in the angle of elevation, and 14 feet per 1000, in the distance —the theoretic angle of elevation being 4°, 17′ 55″.

In the same manner, 10 revolutions would have a falling off of but 10″ from a theoretic angle of 2°, 52′, with a corresponding shortage in the distance of but 5 feet per 1000.

Again if we give the Gradienter screw the number of revolutions corresponding to 90°, the telescope should be elevated to a perpendicular position, and the reading of the rod should be *infinite*, to correspond with the popular theory of the instrument.

But, on 100 feet radius, the arc described is 78.54 feet. But as this arc has been projected in the direction of the tangent, the elevation of the telescope is only that due to so much tangent, or 38°, 9′,—so wide is fact from the popular theory,—and the reading of the rod is 78.54 feet, instead of infinity.

If we should require to work up an incline of more than about 3°, we should first slack the clamp, and turn the telescope up to the given elevation, before clamping the Gradienter to the telescope. By this means we preserve the available part of the Gradienter for the reading of the rod.

It will be remembered that two years ago I presented a paper on this same topic. But after a time some further explanation was asked for, but before I could make it, our report went to the printer,—thus the article was not published.

In this treatment I have endeavored to be so full and elementary that further explanation will not be wanted.

I gave, too, a method of making corrections for angles greater than 3°, by means of a table of errors.

A better means of avoiding error is to be found in modifying our telescope. *Use the inverting eye-piece.* By this means, with a given length of tube, we may have a *greater focal length*, and as a consequence a *greater power.*

We will have, too, *more light*, because of less loss by absorption. And, with the greater focal length of object glass, we will have better *definition*, because of less spherical aberration.

With the above advantages we may *shorten* the unit of measure on the rod,—say make it .4 instead of .5 of a foot at 100 feet, for one revolution of the screw. This will help to keep the angle of elevation of the telescope within the limits desired.

H. C. PEARSONS.

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ILLUSTRATED MANUAL AND CATALOGUE SENT ON APPLICATION.

INITIAL WORK ON THE MEXICAN BOUNDARY LINE SURVEY, IN THE YEAR A. D. 1849.

ENGINEERING, civil and mechanical, has made great progress within the last half of the century. The achievements of the modern engineer, bold, practical, many-sided and far-reaching, excite astonishment. In the mediæval ages such marvelous exploits would have won for him the name of wizard, and his reward most likely would have been a fiery trial at the stake.

From the advanced position attained, in the face of accomplished facts, members of this honorable Society will pardon me for asking them to go back with me to a period indeed full of interest and enterprise, but not illuminated by the brilliant light of modern science and art.

Forty years in this "rapid transit" age, when steam and electricity are prime factors, is a long step backward. The distance is immense when measured by the world's progress during that time.

In 1849 the Mexican War had closed. The newly acquired territory of California was a remote region to be reached only by sailing around Cape Horn or perilous overland journey over high mountains and across inhospitable deserts controlled by savage foes. Farther India and China were better known to the civilized world than fabulous California.

In 1848-49 the people of the Atlantic States were startled by whisperings of gold discoveries at Sutter's saw-mill, on the headwaters of the American River.

These whisperings, faint at first, and hardly credited, soon became so loud-voiced, that their echoes went resounding through the world. Then began a rush and scurry of people to the new El Dorado as had never been seen. The Crusades, precipitated by the preaching of Peter the Hermit, were nothing in comparison, as to numbers and results.

The lust of gold proved more absorbing than religious zeal. The whole world was aroused. Hosts from all lands, by devious and difficult ways, rushed for the foot-hills of the majestic Sierra Nevadas, confidently hoping to find in the golden sands, fortunes unlimited.

Meantime, portions of our army, fresh from the victorious battle-fields of Mexico, in order to take possession of this newly acquired land, in the name of the government of the United States, were slowly fighting their way across the continent or being tossed by ocean waves, in sail vessels, on the long voyage around South America. Simultaneously, or in the

winter of 1848–49, the Government organized and sent out a commission to survey and mark a boundary line, under the treaty with Mexico.

The commission consisted of Col. and ex-Governor Weller, of Ohio, Col. A. B. Gray, of Texas, the first named, Commissioner, and the second, Surveyor, under the treaty. Attached were about fifty gentlemen, surveyors, engineers, secretaries, a surgeon, and quartermaster, all civilians, drawn from many States.

Major Emery (afterward General), was chief astronomer and commandant of escort. On his staff were several young U. S. engineers and a corps of computers. The military escort was to join the commission at San Diego. San Diego, on the Pacific, was the designated point at which the survey was to begin and where the commission was to rendezvous. The route by the isthmus was the one selected to move on. At that time it was difficult to reach California by any route.

The headquarters of the commission were at New Orleans. It was no easy matter to reach even that point in those primitive days in winter. There were no railroads from Detroit to Buffalo; none from Albany to New York, direct, and very few south of Washington.

After some delay at New Orleans, the commission, with instruments, provisions and stores, finally embarked on a government steamer in January, and sailed for the port of Chagres, on the isthmus. Canoe transportation was used on the Chagres River as far as Gorgona, and mule trains thence over the mountains to the City of Panama, on the Pacific side. At that time surveys for a railroad were being made.

The commission was detained three months on the isthmus for lack of transports.

As yet, there was but one steamer on the water between Panama and San Francisco. She had sailed north not to return very soon. Her crew deserted her as soon as she reached California and hastened to the mines.

After a while the second steamer arrived from around the Horn, and took on board a detachment of the commission. The third steamer which sailed from New York after the commission had left New Orleans, under command of Captain Porter (later an admiral), put in an appearance in May. By strong pressure on the part of the government, the remainder of the anxious commission was received on board that ship.

Panama was crowded with adventurers. They were in great stress. To the unacclimated, the dirty, close-built, walled city was a hot-bed of fever. The imprudent, ill-fed,

anxious northmen sickened and died rapidly; cholera followed in their wake. This was a new disease to the nation and filled them with terror and consternation. They died by hundreds. Wailings were heard in almost every house, as when the first-born were smitten in the land of Egypt. Priests with bell, candle and incense paraded the streets; trains of powder were lighted and cannon fired to drive away this mysterious plague.

The desperate California adventurers were mad to escape from this wretched city. They seized upon every available mode of egress. Whalers, merchant ships, schooners, sloops, yawl boats and even the native dug-out canoes were pressed into ocean service as transports. It was a dire time. Strange to say some of those small boats and canoes, after months of peril and hardships, reached Lower California. The strong northwest winds prevented further progress.

The steamer which carried the writer, though crowded to suffocation almost, in due time arrived at San Diego. The voyage near the coast line of Central America and Mexico was very pleasant. The Pacific Ocean did not belie its name.

The writer's first experience of California, was a hard night spent at Point Loma, in one of those hide-houses so graphically described by Dana, in his work entitled "Two and a Half Years Before the Mast." Twenty-two thousand hides were stored therein. Though dried like horn, these cast-off wrappers of California's ancient wealth—the cattle on a thousand hills—were malodorous and the trysting place of innumerable fleas. A couch on these bullock hides was anything but a bed of roses.

The Pueblo of San Diego, at which the commission took post, lay several miles inland but still near the bay, on a small stream, dry most of the year. A little adobe-built town of low, red-tiled houses, built around the plaza. A few outside buildings completed this isolated Spanish town. The fine bay of San Diego, roomy enough for a large ocean fleet, lay in front, and beyond, the Pacific Ocean in its vast expanse. In the rear, bare, rounded hills were succeeded by distant azure mountains. These, and a salubrious climate, were the chief attractions.

The stars and stripes were floating gracefully from a tall flag staff in the plaza, and we Americans saluted the flag with joyous shouts, with some tears welling from our eyes.

The natives of the country, their habits and costumes, have been so often described, I will not dwell upon them.

There were plenty of horses and cattle feeding on the hills —the only wealth of this section.

The roll call, made about the first of June, found all the members of the American Commission present in San Diego. Several companies of U. S. troops were posted there. Many of the officers with the command, afterward in the war on the Union, became distinguished generals and freely shed their blood for their country, Emery, Heitzleman, Lyon, Whipple and others. The Mexican Commission had not arrived, but came in on the last of June. The Commissioners, a distinguished Mexican general, Garcia Conde, and Senor Salazar, surveyor under the treaty, with a large corps of surveyors and engineers and staff officials, were many of them accomplished men, speaking besides Spanish, French and English. The interpreter (each commission had one), Senor Iturbide was the son of the ex-Emperor of that name, and had been educated in Philadelphia.

The Mexican army escort was a disreputable band, without uniform, and taken from the prisons of Mexico mostly. I speak of the common soldier. Subsequently we Americans found them to be an element not of defense but offense,—more to be feared than the Indians. Many women were with them as camp followers.

On the 4th of July, the American Commission gave the Mexicans a dinner and ball. It would be hard to tell which side was most gloriously drunk—with patriotism.

At length, after long waiting, a program was formulated, and actual work on the boundary line survey begun.

According to treaty stipulations the boundary line, in general terms, was to be run as follows:—

Beginning on the shore of the Pacific Ocean, one marine league south of the southernmost point of the Bay of San Diego, thence easterly to the junction of the Gila with the Colorado River, thence up the Gila to its source, thence across to the headwaters of the Rio Grande, thence following down the middle of that stream to the Gulf of Mexico.

In passing, I beg to state that THAT is not the present boundary line between the two republics. By the Gadsen purchase, in 1853, the line was carried further south so as to include a portion of Sonora, now known on the maps as Arizona.

The camp of the chief astronomer was moved to the head of the bay, some 15 miles south of the Pueblo. The surveyor's camp was pitched near it.

The initial point of the line was to be fixed astronomically. Also the point at the mouth of the Gila.

A party of astronomers were at the same time sent to the Gila under Lieut. Whipple, U. S. Engineer, afterward General Whipple, killed at Chancellorville, Va.

A line drawn on the map from the astronomical point on the Pacific coast to the astronomical point at the mouth of the Gila, would give the course to follow and mark on the earth's surface as the true boundary line.

The surveyor, Col. A. B. Gray (later on the Confederate engineer who fortified Island No. 10 in the Mississippi River, and was accidentaly shot to death on board a transport), organized his forces for field work. His assistants were a motley group—mostly political appointees, and as innocent of surveying as sucking doves. A few were trained engineers, surveyors and draughtsmen of experience.

Mr. Gray's first duty was to measure the marine league before spoken of. A survey of the bay of San Diego had to be made in connection.

The measurement of the marine league was assigned to the writer; the survey of the bay to Charlie Whiting, a West Point graduate (later on a colonel of cavalry in the Union army).

But, before proceeding to work, Col. Gray ordered the writer to make a topographical survey of a small valley leading to the old mission of San Diego, six or seven miles from the Pueblo.

The writer chose his party from the young gentlemen who, on the voyage out, had constantly boasted of their engineering skill and experience. The instruments to be used were a common chain, compass and a level.

We started at the flag staff, the writer kindly managing the instruments until beyond the reach of critical observers in the Pueblo. Then he told his assistants to take the instruments and go ahead, nicely sketching in the topography in their field books. But no progress was made, Mr. H. at the compass being in doubt as to which was the north end of the needle. Mr. E. declared there was nothing to sketch but a straight line from one station to another, and so on. The survey was not completed, but an inglorious retreat was made to headquarters, where a game of poker restored the good nature of our skilled engineers. Comment is unnecessary.

The writer then made up another party from young men who had all along admitted that they were entirely ignorant of practical surveying. They were well educated law students

from the northern States. By a little drilling they soon became efficient workers, and in the course of time formed an admirable party. Many of our political appointees never did a stroke of work on the survey.

Perhaps you may have observed that no mention of common men has been made, and it would seem that the Commission was made up entirely of officers. This is true. There were really no "high privates." Some destitute emigrants from Texas, stranded on this shore without a penny, consented to work awhile to recuperate their finances, before going to the gold mines. The cook in our camp, who had acquired some skill in turning flap-jacks, while coming across the plains, was paid $500 per month, while the writer received $800 per year and rations, and the first assistant $1000 with a liberal supply of hard tack and *carna*. These terms were made on the Atlantic side, before the discovery of gold, and was considered good pay *there*.

During our first summer in San Diego, in Uncle Sam's employ, the embryo cities of San Francisco, Sacramento, Stockton, and others, were springing up and expanding. We were offered $1000 per month, with city lots thrown in, to go there and lay out the towns. But under these great temptations we remained true to our colors, every man. How this fidelity was rewarded by a generous, paternal government will be seen further on.

There was nothing difficult in the survey of the marine league. The country crossed by it was low, level, pasture land, dotted with clumps of sage brush. The land was cleared and leveled. A French metre chain was used in the measurements. It was carefully stretched by a spring balance. It was aligned by a theodolite, and was transferred by careful offsets. The work was done accurately but rapidly. No such precision, however, was required as in the measurement of a base line for triangulation. The initial point was soon fixed on a commanding bluff, and a stone monument set up there. Later the joint commission assembled at the place, and with some speech-making, and breaking of champagne bottles, dedicated the monument.

The Mexican surveyors were supposed to be assisting in the work on the marine league all the time. But they never took a hand in. Occasionally a few gaily dressed fellows, with jingling spurs, would ride down upon us and criticise the plebeian Americans, who would stoop to work, in pure Castilian.

From first to last, while we were there, the Mexican

surveyors did no work unless in the night time. How they amused themselves we were too busy to ascertain. But it was decidedly a one-sided survey, the whole of it. Yet we Yankees were content to have it so.

The chief astronomer, after months of "star-gazing" and reams of computations, finally *fixed* the initial point on the face of the earth to the satisfaction of all concerned. In order to do so, some nice triangulation was necessary.

His special work done, the writer spent a pleasant month or two with engineer Whiting on the survey of the bay. In that glorious climate, with cloudless skies, our duties were delightful, and camp fare good. Game was abundant,—deer, jack-rabbits, quail, and curlew could be had at all times. The waters teemed with fish, notably herring, mackerel, and rock cod. The only drawback in surveying and hunting was the fear of rattle-snakes. They abounded in great numbers in the tall grass and cactus and sage brush. We had many narrow escapes. The Mexican soldiers killed them for food.

While this work on the coast was progressing favorably, the astronomical party at the mouth of the Gila was busy star-gazing, much to the astonishment of the wild Indians.

A semi-military expedition was sent out from the coast across the Cordillera range of mountains, to explore the country and to establish a signal station, on the east side of the range, where the towering escarpments offered a wide view of the great desert and of mountain peaks on the far-away Colorado.

By preconcerted action, on certain nights, rockets were sent up from this station and at the one near the mouth of the Gila on Pilot Knob. The object was to thus determine the difference in time—longitude—between the two places. But the rockets were not seen, from some cause not explained. The distance between the two points, on the air line, was about 100 miles. So this party returned to camp, *not* covered with glory, but with fabulous stories as to hardships and hostility of the Indians.

In October, 1849, a grand effort was to be made. It was determined to send a party to the Gila, 200 miles away, across the unexplored mountains and desert, following as near as possible the assumed boundary line. Col. Gray, surveyor, was in command. The writer acted as his assistant. We were well fitted with a train of pack mules, carrying surveying instruments, blankets, and rations. The officers, cook, muleteers, guide, and four men constituted the party, escorted by a corporal's guard of infantry *on foot*. Cavalry would have been more

efficient. Our rate of progress was at all times fixed by these *foot-men*,—an absurd arrangement!

The speed of progress was timed, and it was found after several tests to be about three miles per hour. Thus was the distance from camp to camp roughly obtained. Topographical sketches were made by the writer on mule back. Sextant observations were taken at night. The invariably clear skies favored such work. Detestable work it was after a long day's march across those rugged mountains! Four or five hours sleep was all; too little to recuperate our worn-out bodies.

But the journey across the mountains was full of interest, and the air as exhilarating as wine. Grand peaks and deep gorges everywhere; some tall climbing was done and much rapid sliding. Desolation seemed to reign; the eyes tired of gazing upon the bare, broken, glaring, yellow rocks and jagged peaks. But as we struggled forward, hot and jaded, our trail would descend a narrow winding gorge and finally lead us out into a beautiful grassy valley, with a murmuring stream of sparkling water winding through it and lined on either hand by far-spreading, live oaks, whose shining, deep green foliage was very refreshing. There were many such valleys *en route*, and they afforded us delightful camping places, where we fain would have lingered many days.

As we marched, day after day, not a living thing was seen outside of our own party. There was some little shrubbery noticed outside the valleys. An occasional oak tree or rather shrub, loaded with clusters of sweet acorns, and some scrubby plum trees, were all that we noted. Once in a while a stark, leafless cactus plant obtruded upon the vision, adding to the desolation of the scenery. We found numerous *caches* filled with acorns, evidently the Indians' stores for winter. But where were the dreaded Indians we had heard so much about? Lurking somewhere no doubt. The solitudes were so profound that the sound of our own voices would often startle us. As we penetrated deeper into the recesses of the silent mountains we began to notice on commanding peaks in advance, tall, thin columns of smoke shooting up. These were the alarm fires, or signals of the Indians. They were evidently tracking and watching us. At length a bevy of these naked savages dropped into our camp. They were armed with bows and arrows, and were by no means hostile. A gift of hard-bread and tobacco increased their good nature.

They squatted around our bright camp-fires ready to snatch at any food thrown to them. When bed-time came, they were driven outside the line of sentinels. Instead of

building a fire for themselves, they would dig a hole in the sand with their claw-like hands, like a hog wallow, and crowd themselves into it for warmth. They were miserable "diggers." They disappeared in the morning, like dew, and were no more seen until the following evening.

During the night we found the air so chilly that we kept our camp-fires blazing and a pair of heavy blankets in addition to our clothing—none too much for comfort. We had no tents, but threw ourselves on the ground with feet to the fire, and a saddle for a pillow, and slept like very tired men.

Often baffled and turned from its course, the party nevertheless made steady progress eastward, coming out finally on the eastern escarpment of the mountain range. Before us lay spread out the great desert, looking through the shimmering heat waves, like a great yellow sea, stagnant and sullen. Where we stood, nothing but huge boulders and jagged peaks, crumbling and falling, met the eye. No water, no vegetation, only glaring rocks which struck terror into the stoutest heart. The air was so light that a shout, a musket shot, could be heard only a few feet. There appeared to be no break in this solid battlement through which we could escape to the desert. The situation was full of gloom and doubt. We *must* get out of this! And, after toilsome searching, a detached party found a slight break which would just let the mules crowd through. Down we plunged, the mules often sliding hundreds of feet on their haunches. As we advanced, the gorge widened, and before we had reached the plain, became a narrow valley, with signs of water. Six hours were consumed in the descent. The cool, pure air of the mountains we left behind only to plunge into tropical climate. As we defiled out of the gorge, hot, tired, ragged and parched with thirst, we suddenly struck a stream of running water—Carrizo creek. To plunge noses into it, both man and beast, was the work of a moment.

Carrizo creek is shallow; the waters well up suddenly, run a few hundred yards, over a sandy bed and then disappear,—a peculiarity of many western streams.

Resuming our march, we soon struck the emigrant trail in the desert. This Colorado desert is about ninety miles wide east and west, and was doubtless once the bed of the ocean—an extension of the Gulf of California. It is a level expanse with little vegetation. The road now passed over long stretches of clay and gravel, alternating with loose sand. Numerous dry arroyos were crossed, some of them many yards wide, with steep, clearly outlined banks—in fact, rivers without water. No water could be found. Heat and thirst became trying.

We camped the first night on the desert, without forage or water. The distress of the poor mules was pitiable. We passed numerous emigrant trains toiling toward the land of gold. They had spent six months in the wilderness; they were worn out, ragged, half starved, impoverished, almost hopeless. The splendid trains with which they started in the spring were reduced to a sorry condition. Horses, cows and mules, singly, or two of different kinds, were hitched to dilapidated wagons, or carts, extemporized from broken wagons. Some families were reduced to an ox or cow upon which their baggage was packed, while the men and women trudged slowly along through the deep, burning sands. They were objects of pity.

On the second day of the desert march we reached Salvation Camp. At this point blessed water was found; oh, how it was enjoyed. We were told that only a short time before, these springs burst out of the arid plain, as if by a miracle, to the salvation of hundreds of perishing emigrants.

The next year, hot mud springs were found there. All these phenomena were doubtless the effect of earthquakes. On our march we felt several shocks, and were almost overcome by the heat that accompanied them. The sky was like brass, the air still and hot as a furnace.

We found many hundred people resting at Salvation Camp. In the rich soil, grass had already sprung up, proving that the desert only needed water to show its fertility.

Among the emigrants we found a large corps of U. S. officials sent out to take possession of the custom houses in California. Mr. Collier was collector. A squadron of dragoons guarded the train. The whole body was in a starving condition, living on one-fourth rations. They were clamorous to be led by our new, short route to the coast. Col. Gray consented to act as the Moses to lead them out of the wilderness into the land of promise. He ought not to have assented; his duty was to lead to the Gila in the opposite direction. But the pleas of starving men were powerful. He ordered the writer to continue on to the Gila, and make the necessary surveys. The writer remonstrated, hinted that the supervision of that work, on the part of the surveyor, the only person known under the treaty, was imperative; that he would conduct the Collier expedition into California. "Oh," replied the Colonel, "YOU cannot find the way with them." The logical question followed this reply. "If I am incompetent to conduct this expedition over a fresh trail, how in the name of Sinbad, am I to get back with my own party, a

month hence?" The answer was, an order in writing, to "pull out" at 7 P. M. Sunday evening.

Obeying gracefully (*because he had to*) the writer only stipulated that he should not be bothered with the corporal's guard, which was accordingly left at Salvation Camp. Four men were selected to go with him, including a soldier, without his musket. Each person had a mule to ride, and there were several pack mules in the train to carry instruments, provisions and baggage. A rapid march was what was aimed at, hostile Indians were a secondary consideration.

Promptly at 7 P. M. the little party bade adieu to anxious comrades and departed. It was a clear, starlit night, and the commanding officer took his course by the stars—an effort to follow the emigrant trail soon proved futile. The shifting sands speedily obliterated all footprints, leaving us adrift on the desert. The march was slow, not faster than a walk. The commander had to be constantly on the alert in order to keep on his course, and prevent his sleepy, tired men from straying. Often they left the line, and often they tumbled headlong from their mules, having fallen asleep in their saddles. When it was necessary to stop the train to adjust the baggage, the idle ones would immediately fall asleep on the soft sands.

In the morning, Cook's well was reached. By digging, we obtained some brackish water with which to boil our coffee. After an hour's stop we resumed our march; we toiled and waded through the loose sand sullenly, almost hopelessly. The sun was intensely hot, and the fine, impalpable dust powder of the desert, hung to us, like a mist, filling eyes, nose, mouth and ears with dust. Even our clothing was saturated, and our sweating faces were plastered with it, so that the Indian was fair in comparison. Thirst, the greatest of all the traveler's afflictions, tormented us. The brackish water in our canteens, from Cook's well, became so tepid and slimy that we threw it away. Our lips became swollen, cracked open and let the blood run out. Our tongues became so swollen that articulation was difficult. Faces became haggard and eyes staring, through their grimy masks. Our pack animals shared in the common distress. Riding became so fatiguing that a change to foot was often resorted to, but was speedily abandoned. In the loose, deep sands a walk of a few hundred yards would exhaust one.

This dreary march was enlivened, if such misery could enliven, by numerous passing trains of weary, way-worn, starving, almost hopeless, emigrants. The route was marked by broken wagons, the irons of wagons, which had been burnt

for fuel, by trunks, boxes and furniture, by dead mules, oxen, cows and horses. Not infrequently we saw little mounds of sand with stakes at head and foot, whose purpose was unmistakable. With grim humor some American had placed a dried skeleton of a horse or ox on its feet, with head and tail erect, with a legend, "This is the way to the gold mines." Carcasses in this dry atmosphere never became putrid, but in this case in the starved animals, there was nothing to putrefy but hide and bones.

At 4 P. M., after leaving Cook's well, we struck an Indian village on the banks of the Colorado. Thrice welcome river, never was anything sweeter than this yellow flood! We were now fourteen miles from the astronomical camp at the mouth of the Gila.

But we came near not reaching that haven. The men tired and worn out, and attracted by the pleasant Pimo village, with its green pastures and cornfields, and, perhaps, by the half nude young squaws which met their gaze, were determined to stop for the night. To have done so, would probably have been death to all. There were mutinous displays, but the commander, placing his troop in front, drew his revolver and ordered it to trot for life. None too soon did we escape from the village; a buck, with hostile intent, intercepted us, and the commander had to knock him down with his horse pistol, because of presumption in seizing his bridle. We hurried up the river, in hot haste, the Indians following. But fortunately they had no horses, and were armed only with clubs.

These Indians were at heart hostile, and were only kept in check by the camp of U. S. dragoons stationed at the Gila. After this force was withdrawn, they attacked and killed a party of emigrants. Two companies of militia were sent out to chastise them, and did it so effectually as to annihilate the village.

At 10 P. M. we rode into camp at the Gila, after twenty-seven hours of continuous riding. We were heartily welcomed. Lieut. Whipple, of the engineers (in after years he laid down his dear life on the fatal field of Chancellorville), took me to his tent and fed me.

Our commander, after a hearty supper, unwashed and full dressed in his dirty suit, threw himself on the ground and slept twelve hours solid without stirring. One day was required for rest. On the second day of our arrival, a survey of the junction of the Gila and Colorado was made by triangulation. Our transit instrument was so badly jammed as to be

useless. Lieut. Whipple kindly lent his theodolite. There were no boats to be had, so Dr. Parry swam the swift stream (Colorado) and set up stakes for me at the mouth of the Gila.

Time and space will not permit of a description of this place. Suffice it to say, if there is a hotter place on the continent, in October, than at the mouth of the Gila, the writer has not found it; and if there is a land more sandy, more rocky, more sterile, more terrifically desolate, than this washed by the Colorado and Gila, geographers would have difficulty in pointing it out. Some profane person has aptly described the region as a "hell on earth." There is but one redeeming feature in the landscape, namely: the grand, jagged, many-colored, heaven-aspiring mountains, crossing the eastern horizon. These are best appreciated in the distance.

The return march to San Diego was full of toil, danger and suffering, for starvation was added to the list of hardships. We reached Salvation Camp more dead than alive. Our corporal's guard was well, but had about given us up. Col. Gray had fed the Collier party so well that no provisions were left for the surveying party. The writer subsisted for several days upon a handful of broken crackers each day, which the corporal kindly gave him from army rations. No time was lost. We pushed forward toward the sea with what energy was left.

Twenty-five miles from San Diego we reached a Spanish rancho. Here we encamped. A sheep was purchased, butchered and boiled in a camp kettle, and, as soon as cooked, was devoured at one short sitting; the whole command participating. Famished wolves could not have shown less ceremony.

At length the writer, with his little command, reached headquarters without loss of a man, beast or baggage.

On reporting to the commissioner, we found that august official lying on a cot, ill from a pistol shot. Displeasure at the untimely return of Col. Gray, with the Collier party, roughly expressed, had caused a row, in which the commissioner was shot by a revolver in the hands of Col. Gray. Pistol practice and the duello were quite fashionable in those days.

The commissioner was pleased to say to the writer that he would commend him highly in his next dispatches to Washington.

Those dispatches need not have been sent for all the good they did. Note results further on.

Thus ended the work on the Mexican boundary line survey for the year 1849. The approaching rainy season, it

was assumed, would stop the work, if there were no other reasons for suspension.

An election of two United States senators was to occur at Monterey in the winter. Col. Weller was an aspirant for one of these positions, for the new State of California. But before he left us he had been removed, or expected to be, by the new administration under General Taylor.

Col. Fremont was nominated as his successor as Commissioner, but we never had a glimpse of his distinguished person. He too had a senatorial bee in his bonnet. He cruelly left us to our fate. The grand Commission, in the absence of the high officials, was reduced to a pitiful lot of young men, quartered during the long rainy winter, in the mud hovels of San Diego, or in tents, without one cent of pay, subsisting upon hard bread and tough beef. There were no books and no amusements except gambling. Finally an agent was sent down to settle with us, giving unnegotiable *due bills* on the government at Washington. We were not dismissed, nor disbanded, nor mustered out, simply let alone. Our contract with the government required that we should have transportation home. At that time a steamer ticket to New York cost $500. No promises for the future were made. The resumption of work on the line depended on future appropriations by Congress,—so did the cashing of our due bills.

Thus incontinently "left" in a foreign land, as we looked at it, with no hard bread and beef guaranteed, there was nothing left for us to do but "move on," like poor Joe. The writer, by hoarding, after 14 months' faithful service, had money enough to buy a steerage passage on the steamer Oregon for San Francisco. He wrote to his father for redress. A member of Congress from his district was appealed to. An answer was received to this effect:—

"Whereas, your son deserted from the Commission and ran off to the gold mines, therefore, resolved, that he is not entitled to favorable consideration, but, on the contrary, should be punished."

As before stated, this base son of a worthy sire, was tempted soon after he landed in California, to desert his post, in consideration of pay at the rate of one thousand dollars per month and city lots thrown in. But he and his comrades stood by the colors until there were no colors to stand by.

Some of the methods of our Uncle Samuel are very queer indeed. No honest man will ever fall in love with those methods, or submit to them longer than possible. If Indian agents and others do, in self-defense, cheat our venerable

relative, the writer will not be the first man to vote to send them to purgatory. The gratitude of republics is inspiring.

JOHN H. FORSTER.

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A. C. BOTH,

Civil Engineer, PORTLAND, ME.

PROGRESS OF DRAINAGE IN THE HURON PENINSULA.

A GLANCE at any map of the Huron Peninsula will show that in its central portion is the source of the following rivers, viz.: Cass River with its several branches, whose waters find an outlet in Saginaw River; Black River, with its main branch, Elk Creek, finding an outlet in St. Clair River, also the Pigeon, Barques and Willow Rivers, with outlets in Saginaw Bay and Lake Huron. Closer examination will show that this district comprises almost the whole of Sanilac County, a few of the southern townships of Huron County, bordering on Sanilac, and a few of the eastern townships of Tuscola County. At the headwaters of these several streams are uniformly found marshes or swamps, varying from a few hundreds of acres to several thousands of acres in area, and it is the reclaiming of these marshes and converting them into tillable and valuable farming lands that constitute the drainage operations of the "thumb" of Michigan. Each of these marshes is, for the most part, nearly level, but all occupy elevated plains not less than from 200 to 300 feet above the mouths of the various rivers which form their final outlets. The largest and most important undertakings, and the ones that, if any system could be followed, should properly be done first, are not yet commenced; that is, the opening of large channels at the head waters of these different streams to make the main outlets for a more thorough system of drainage. On the contrary, owing to unavoidable circumstances, the drainage goes on piecemeal, by making one small drain here and another there, as improvement and settlement of the land demands. These, for the most part, seek outlets in the sluggish head waters of the streams already mentioned.

Notwithstanding this want of system and inverted order of proceeding, the work already accomplished is very valuable, and is, perhaps, the best that could be done with our present drain law, and the partially developed condition of our country.

To make this more plain, allow me to introduce a few words regarding the agricultural history of the Huron Peninsula, for drainage and successful agriculture go hand in hand, though remember, it is only surface drainage to which I shall refer. We are not far enough developed to do much in the way of tiling.

Every one knows that, originally, this peninsula was covered with some of the most valuable pine Michigan ever pro-

duced, but unlike the light and almost worthless sands of the central and northern portions of Michigan, it has a loamy soil, inclining to clay, rather than sand, yet not unduly hard. Again, this land is interspersed with the marshes already referred to. These marshes have a mucky surface with clay subsoil, the muck varying from a few inches to several feet in depth, usually, however, not deeper than two or three feet.

It was not until two or three years after the fire of 1871 swept over the country, that lumbering ceased and agriculture really began. For several years it progressed slowly, for the inhabitants of a lumbering country are loth to give up the old pursuit and settle down to agriculture as a business, and not till several years had elapsed, and many of the woodsmen had moved out and given place to settlers who are really farmers, did the business actually change, and the peninsula forsake the aspect of a lumbering country and appear like one given to agriculture. The fire of 1881 followed, and immense tracts of windfall and dead timber were cleared as if by magic, thus offering opportunities to the poor man in search of cheap homes, and good lands, unrivaled only by our western prairies. Immigration rapidly followed, and soon the entire peninsula was settled with sturdy farmers living on small tracts of land of which they were the real owners.

About this time the drain law of 1881 appeared, which, though imperfect, took long strides in advance of the old law which had produced little but litigation and disgust. An impetus was thus added to drainage, for the people were ready to demand it, and many miles of drain were successfully constructed. Other amendments have been made in 1885 and 1889, but all are in the old groove, no practical changes having been made.

This now brings us face to face, ready to talk intelligently about our subject, as we find it today.

As already seen, Sanilac County includes the largest part of the drainage area in question, and I find that the work is nearly all being done in Sanilac County. The Huron County drain commissioner reports on hand 17½ miles of drain, which he hopes to complete this year. The Tuscola County commissioner reports but 8 miles, while the Sanilac County drain commissioner will complete upwards of 50 miles and has 100 miles in process of construction. Huron and Tuscola Counties have each less than 10 miles of drains in the hands of township drain commissioners, while Sanilac County could show more than both, being constructed by township drain commissioners.

One township, Koylton, in Tuscola County, deserves especial mention for the systematic way in which it has taken up its drainage, under its own commissioner. It has constructed, in the last two years, in a first-class manner, about 7½ miles of drain, at the head waters of White Creek, making a ditch 8 feet wide on the bottom near the outlet and 3 feet at the upper end, and averaging about 4 feet in depth, with slope of banks 1.1. Also 6 miles of laterals tributary to this main outlet. These have been done at moderate cost. Sanilac County has completed many as successfully, some being longer, but in no other case has a district been taken up and as thorough work made as in the township mentioned.

The excavating is mostly done with teams and scrapers, or with shovels, the work costing from 8 to 12½ cents per yard. The contracts are all let at public lettings to the lowest bidders at prices given per rod.

We offer a fine field for dredges to operate in, but under our present law the pay is too insecure to induce contractors to bid. In the near future, we hope to take up the head waters of Cass River, and make a good channel for a distance of about 14 miles, and to do the same with Black River and Elk Creek for somewhat shorter distances.

Our actual progress, though considerable, is not what I hoped to be able to report when I promised to write this paper, and really I am not proud of it, when I read of what is being done in some of the drainage districts of Illinois. Even as it is, the work accomplished is valuable, and it would not be exaggerating to say, that the drains are adding value to Sanilac County of not less than $75,000 per year.

METHOD OF STAKING OUT.

The manner of staking out used by most engineers in the peninsula, as well as myself, is essentially the same as described by Prof. Carpenter in his paper on drainage, and already published in our proceedings. But, knowing how eager young men are for details, I will give a few, at the risk of repeating, hoping that in so doing I may help some beginner, and thus partially pay the debt I owe the older members of this Society for similar articles. We stake the center line marking the stakes from the outlet, as the law requires, and set stakes at 2 chains, or 8 rods apart (I would prefer using the 100 foot tape, and staking every 100 feet, but have not yet tried to break over the custom). If the drain commissioner is with me, I appoint him flagman, and direct him to go ahead to a point where it is necessary to change the course, or, if

that is too far, to some point on the already determined line. Then the chainmen are started in, the rear chainman swinging the other into line between himself and the flag. They use three marking pins, two being carried ahead each time, thus leaving one in the ground at the stakes, from which to measure. When the two pins taken ahead are set, the head chainman calls "*stake*," and a man with stake and ax steps into line at the pin, facing the transit man, who gives exact line, and sees that the stake is kept in line till driven. The stake man then proceeds to the next stake point, having procured a stake from another asssistant. In the meantime the rear chainman has dropped his end of the chain, walked ahead to the stake, and handed his two pins to the head chainman, and the work proceeds as before. When an angle point is reached, the head chainman stops, holding the end of the chain at that point, the rear chainman steps forward to the last stake or pin and reads the chain, calling it out to the transit man, who makes the proper record. The transit man also records the magnetic bearing of all courses.

For leveling, stakes are set opposite each center stake, far enough one side to be on the berm of the ditch, between the excavated earth and bank of the ditch. At each of these stakes hubs are driven level with the surface of the ground. The levels are taken on these hubs, and the hubs remain there for the use of the contractor in digging and the commissioner in accepting jobs. This system of staking out, where good work is done, good stakes and good hubs driven, gives the best of satisfaction. The surveyor should not do slouchy work, nor allow any of his men to do it for him. He alone bears the praise or blame, according to the success or failure of his work.

I keep alignment notes in a tabular form much as shown by Beden in his valuable paper on Drainage, already published in our proceedings. The table shows method:—

Angles.	Bearing.	Station.	Chains.	Course.	Remarks.
0	N. 25° W.	0.000	0.000	20.25	"0"=4 chains
1	N. 40° W.	10 + 0.25	20.25	21.05	east, and 15
2	N. 30° W.	20 + 1.30	41.30	38.70	chains south of
Terminus		40 + 0.00	80.00		n.e. cor. sec. 10,
			Proved, 80.00		t. 10 n., r. 12 e.
					Terminus=Etc.

I keep topography notes on the right hand page of level book, using for right, the part of the page on the right hand

when standing with face down stream. I keep general width of swamp, as estimated by the eye, or other knowledge, by drawing in an approximate contour of the swamp on each side of a center line and marking estimated widths at abrupt turns and other important points. It is important to show all streams entering the same, their approximate size, and some notes as to character of contiguous high land, character of soil in swamp, and such other facts as naturally suggest themselves. These can form your basis, together with levels, for determining the size of drains. These, too, are copied on the map, not as an infallible guide to the commissioner in assessing, but to aid him in his work.

A profile is carefully made from the level notes to a scale of four chains to an inch, horizontal, and six feet to an inch, vertical. This should show all the facts that can be of use in the construction of the ditch, and give all the data that any other surveyor would need to re-establish the grade at any point.

As our success depends more on the character of the Drain Law than any other one thing, I would like to throw out one suggestion, hoping that it may call out a discussion, though I suppose this is the province of the next paper rather than mine. It seems to me that the great defect in our law, especially for drains of any size, is the manner of working on the credit system, and not raising the money to pay for the work till the drain is located and a tax can be levied on the lands benefited. Thus there are no funds to pay for the work as it progresses, and this makes the work more expensive. But what is worse, non-residents sometimes allow their taxes to be returned, so crippling the treasury as to leave no funds to pay for the work when the orders become due. This causes a sort of uncertainty to hang over the whole business, which very much depreciates the value of orders, and in many cases causes work to be done at speculative prices.

Now if we could have a law similiar to the one in Illinois, or something like the Canadian system, that would allow districts to be formed and bonded for the special improvements, at reasonable rates of interest, pay cash as the work proceeds, and allow the bonds to become due in installments after the benefits have been, at least in part, realized, the now worthless lands would be able to pay their own indebtedness with interest. There is a growing demand for legislation in that line, but just how it should be done I will not attempt to say, for engineers are considered poor law-makers. Last year an attempt was made in the town where I live, and carried so far

as to draft a bill embodying these features, asking for a special act for Sanilac County in view of the large drains we are needing, but it never became more than a "*bill.*"

We live in a wet county abounding in good land (when drained), and are very anxious in this matter. We know that our land is valuable, and can well afford to drain itself if we can only be allowed to go about it in a way that it may be accomplished. And, to say the least, we do not feel grateful when the law-makers in drier sections of the State, not only will not help us in the matter, but will not even allow us to help ourselves.

FRANK F. ROGERS.

NO EXPLANATION NECESSARY.

TOCCOA, GA., February 16, 1890.

F. Hodgman, Climax, Mich.

DEAR SIR:—Prof. Walter S. Wilson, of N. G. A. College, at Dahlonega, Ga., on inquiry by me of him for the best work he knows of on Surveying, sends me your name, as you will see by enclosed letter. Please send me "A Manual of Land Surveying," the book he recommends so highly. He says the price is $2.50; I send check for that amount. If not enough, send the book on and I will remit balance on receipt. Please send the book at once, and oblige,

Yours truly,

LOUIS DAVIS.

DAHLONEGA, GA., February 14, 1890.

DEAR LOUIS:—

Your letter of the 13th inst. was received this morning, and I take pleasure in doing what I can to render you the desired information. The book we used on Surveying was by an English author, Baker, published by McMillan & Co., but the work I am using now as a text-book I consider superior to that one in every particular. It is published by the Engineering Society of Michigan, and is the most satisfactory work, I believe, extant. I purchased it from F. Hodgman, Climax, Mich., who is Secretary of the Society and one of the authors. The title is simply "A Manual of Land Surveying." Col. Price says it is a book that every lawyer should have, as it has the Supreme Court decisions, collected and classified, on every conceivable point that has ever been in dispute before the courts concerning boundaries. Practical suggestions to young surveyors are full, and the theoretical part of the work is in good keeping with the other excellent features.

With many kind wishes for your success, I am,

Your true friend,

WALTER S. WILSON.

To Hon. Louis Davis, Toccoa, Ga.

N. B.—Price $2.50.

The Above Tells its Own Story.

OUR LAWS ON DRAINAGE.

THIS subject may seem anomalous to many members of this Society. There must be others, however, to whom, like myself, it has a practical interest as surveyors.

In our county, and I presume the practice is general, I find it to be the custom of drain commissioners to rely upon the surveyor for advice and assistance in making the necessary papers. As the surveyor's pay for his work depends entirely upon the collection of the drain tax, and this drain tax is based upon the regularity of the proceedings, it may not be amiss to direct your attention to some of the essential points most frequently overlooked.

With a very intricate drain law (I will not say elaborate, for that would at least imply consistency) to work under, and one which no two lawyers will scarcely construe alike, it is theoretically expected that a man who never had to do with law or law forms, aided by defective blanks, will successfully wiggle through the intricacies of the Michigan Drain Law. The court has held that the commissioner cannot pay an attorney out of the drain fund for advice or services, in court, or otherwise;[1] that the forms prepared by the Attorney-General are a sufficient guide; and yet hold drain proceedings fatally defective when they comply with these same forms.

As a prelude, a short history of our drain laws may not be uninteresting or devoid of curiosity. The first Act which I find is in the Territorial Laws of 1819,[2] which authorized the Supervisor "to dig in the highways" and lands adjacent thereto, "such gutters, drains, and ditches therein" as shall be sufficient to carry off the water "with the least disadvantage to the owner of the land," and provided a penalty for filling them up. This Act evidently contemplated that no drainage was necessary except for the benefit of the highway; and the Act of the Legislature authorizing the Supervisor to enter lands was the only right of way then and for many years after, deemed necessary. This Act was embodied in one short section of a dozen lines.

In 1827 the Territory was evidently becoming settled, and something more than highway drainage was needed. In this year it was provided that in case the land was situated so as to be "*conveniently* drained," and the parties could not agree as to how much each should dig, the fence viewers might set

1 Zink *vs* Board of Supervisors, 36 N. W. 73.

2 Volume 1, page 453.

off to each his portion and assess damages for non-performance.

The first drainage Act of the new State was passed in 1839.[1] Any person who deemed it necessary to open a drain through other lands than his own, could have a jury summoned, *ex parte*, who should view the premises of the obstinate party; if, in the judgment of the jury, the damages would be more than the benefits to be derived from the drain, the party applying therefor paid the difference, and in any event, the costs of the proceedings. He could then enter his neighbors' lands "with his servants, teams, carriages, and other necessary implements," and proceed to dig the drain *at his own expense.*

In 1847 an Act[2], supplemental to the preceding, was passed, authorizing the appointment of three County Commissioners "to superintend the draining of such low lands and marshes as do injuriously affect the health of the inhabitants." This Act occupies only two and one-half pages and is but a crude attempt to force unwilling parties to ditch. The Act is historically interesting as first creating the office of drain commissioner, and of authorizing or attempting to levy an assessment for benefits. It contained no provisions for condemning land for right of way, nor were any made until 1861.

In all of the Acts up to 1869, the drain law applied only to lands that could be "*conveniently* drained;" and from the idea of *convenience* probably arose the popular notion that drains could only be laid out in, or following a natural watercourse or swale.

Passing on to the later Acts, I will merely say that our first lengthy drain law was passed in 1869, when the county commissioners were reduced from three to one; that in 1871 the office of township drain commissioner was created, and that our present system was passed in 1885.

My desire was to point out the crudity and ignorant simplicity of our earlier laws. Drain litigation must have been unheard of in those days, and the inhabitants were much more peaceably inclined than at present; for under the later decisions of our courts, not a single drain could have been forced through under those old laws. As a matter of fact, I find but two cases reported prior to 1870; while now, scarcely a term of court passes but what one or more drain cases are disposed of. I shall now call attention to some of those errors, in their order, that should be guarded against.

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1 Session Laws 1839, page 153.

2 Act 104, Session Laws, 1847, page 164.

JURISDICTION OF DRAIN COMMISSIONER.

1 The township commissioner has no jurisdiction to lay a drain extending into, or affecting another township.[1] Nor have township commissioners any jurisdiction to act jointly,[2] as our last legislature made the appointment of a county commissioner mandatory, this is not now likely to occur.

2. The township commissioner has no jurisdiction in or over an old county drain, though the proceedings had by county commissioners were illegal, and the entire drain and lands to be affected thereby, are in one township.[3] It cost one of our commissioners about $400 to find this out. Neither can a drain be re-located or re-established in the line of an old drain illegally laid out.[3 4] Nor can a drain be deepened and widened, in effect, on a petition to clean out.[5]

There yet remain a number of questions as to jurisdiction that are not settled.

1. Under whose jurisdiction is an old drain, wholly within one township, originally illegally laid out by county commissioners, and then later illegally acted upon by township commissioners?

2. Has a commissioner a right to lay a drain across another drain already established?

3. Under a petition to widen and deepen, or clean out, can you also incorporate a prayer to straighten or extend?

These are questions that frequently arise, but as to what answer our court might make to them, I would not hazard a guess.

PETITION.

The petition is the basis of authority to act,[6] and is a much more important paper than commissioners or applicants suppose.

It must show that the signers are freeholders.[7] From the inference of three decisions,[8] it must also state that the proposed work is "necessary for the good of the public health," though this may be waived by acquiescence.

Just how definitely, under the decision, the petition must describe the drain, is uncertain. Under the old drain law, the

1 Drain Com'r *vs.* Baxter, 57 Mich. 127.
2 Hubbell *vs.* Robertson, 65 Mich. 538.
3 Zabel *vs.* Harshman, 42 N. W. 44.
4 Tomlin *vs.* Newcome, 38 N. W. 315.
5 Harbaugh *vs.* Martin, 30 Mich. 234.
6 Kroop *vs.* Foreman, 13 Mich. 144.
7 Frost *vs.* Leatherman, 55 Mich. 33.
8 Butler *vs.* Supervisor Saginaw County, 26 Mich. 22; Kinne *vs.* Bare, 36 N. W. 672; Gillett *vs.* McLaughlin, 37 N. W. 551.

decisions were conflicting, and really required the petition to be based upon the minutes of survey.

Our court has held, under the law of 1885, that it is sufficient to give the termini and general direction.[1] But the court has also repeatedly held that the petition could not leave it to the commissioner to determine distances or direction.[2] Just where the line lies between these two principles does not yet appear.

Our custom has been, especially where there was likely to be a contest, to survey the drain first, and then incorporate the minutes of survey, in full, in the petition.

THE SURVEY.

The survey of the drain must include a description of the land to be taken as definite as would be necessary for a deed.[3] Not only must the commencement, terminus and courses of the drain be accurately given, but also the points of intersection with the lines of every owner;[3] and the width, depth and grade of the drain. It must furnish the data to be acted on by special commissioners or a jury.[4]

These data should not be left for the map and profile to supply, because they must appear at every stage in the Probate Court, and be found there after the proper papers have been returned to the drain commissioner. These data, which the court has held ought to be present, should not, therefore, be confined to the map and profile.

In my own experience, I have used a form like the following:—

Minutes of survey of Coppernal Drain. Commencing in N. E. ¼ of N. W. ¼ of Sec. 8, T. 5 S. R. 8 E., 30 links west of N., S. ¼ line and 4.50 chains N. of the S. line of said description. Thence running as follows:—

Sec.	Course	Distance in chains.	Grade. in.....	Cut.	Bench. .....feet.
0				2.16	
1	South	2.50	20	4.51	W. Oak 5
		2.00	to S. line of	N. E. ¼ Sec. by R. Kerr.	8, owned
2	"	2.50	20	4.00	
a	S. 86° E.	1.00			
3	S. 50° E.	1.50	"	3.90	

a = angle.

1 Gillett *vs.* McLaughlin, 37 N. W. 551.
2 Null *vs.* Zierle, 52 Mich. 540.
3 Mathias *vs.* Drain Com'r, 49 Mich. 465.
4 C. M. & C. R. R. *vs.* Sanford, 23 Mich 418.

The map and profile could be duplicated from these data as easily as from the original field notes. While the surveyor may think that the commissioner should be able to take his own data from the map and profile, practically, he will find but very few who are able to do so.

In the survey of a drain that is to be deepened and widened, I would suggest that the minutes of survey also show the present width and depth of the old drain; else how can the exact quantity of additional land to be taken be determined?

ORDER OF DETERMINATION.

The main difficulty with this paper is to get the drain commissioner to set out the minutes of survey in full; he is generally content with describing the center line of the drain only.

PROBATE COURT.

I have now reached the stage which proves fatal to so many drain proceedings, and which renders a drain tax so fallible. Our courts require as great nicety and technicality as in the proceedings of a railroad company to condemn land, and even greater; for while the railroad company condemn the land of but one owner at a time, the drain commissioner must condemn an indefinite number, and a mistake on one piece vitiates the entire proceedings.

As my paper would be much too lengthy to tell all that is required, I shall only touch on those points held necessary by our courts, and either entirely omitted by our drain law or else hinted at so vaguely as to seem unimportant.

1. The drain law makes no provision for citing those parties before the court who have released the right of way. Yet it is necessary, and their lands must be described.[1]

2. The commissioner must show not only that he has not obtained the entire release of right of way, but that the parties in interest refused to give it;[2] and the application may be opposed on the ground that all have not been asked to release.[3]

3. It must not only describe the lands, separately, to be affected by the drain, but must describe the land to be taken for the drain itself as definitely as in a deed.[4] To save repetition hereafter, I will add that this same accuracy of description must appear in the order appointing special commissioners or jury, or venire to summon jury, in the oath to the jury or special commissioners, and in their return or award.[4]

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1 Stackhan *vs.* Drain Com'r, 39 Mich. 168.
2 Morseman *vs.* Ionia City, 32 Mich. 283.
3 C.M.&L.S.R.R. *vs.* Sanford, 23 Mich. 418.
4 Chapman *vs.* Drain Com'r, 49 Mich. 305.

4. The commissioner must show, under oath, what, when, where and upon whom notice of the citation was served;[1] and in computing time, the day of service and of hearing must be excluded.[2]

5. It must appear that the special commissioners or jury had all the papers before them required by statute, and also proof of service of the citation;[3] and the drain commissioner's report is no proof of service.[4]

The foregoing are some of the difficulties that present themselves on every application; and difficulties, too, that do not appear on the face of the drain law.

I might go on indefinitely as to the errors likely to be made in the apportionment, sale and levy of the drain tax; but here it would practically be of little interest. If the proceedings for condemnation are regular, there will be few litigations; for the contestant will save only the interest on his tax for one year, when it will be re-assessed. As a matter of curiosity, I will add that there is no appeal from the commissioner's assessment against the township at large.[5]

In making drain papers it will be found much more convenient to attach all descriptions of land, descriptions of the drain and minutes of the survey, as exhibits. By this method a set of blanks can be made that will apply to every drain, whether long or short, without using more space than is necessary, or of unduly crowding matter together.

All blank forms issued by publishers that I have seen, and many of the forms furnished by the Attorney-General, are defective and misleading. None of the blank petitions contain any reference to the public health. In the published blanks, the space for the description of the drain is much too small and generally lead commissioners and applicants to the conclusion that a very short, general description is sufficient. The same objection applies to all blanks wherein the minutes of survey should appear. The result is that nothing but general descriptions of the drain appear in the proceedings. There is no provision in any of the blanks for bringing parties into court who have released the right of way. The commissioner had better throw away his published blanks entirely, for all proceedings through the condemnation of land.

As I have been calling attention to some of the blind features of the drain law, perhaps a short criticism upon it would

1 Bennett *vs.* Drain Com'r, 56 Mich. 634.
2 Milton *vs.* Drain Com'r, 40 Mich. 229.
3 Milton *vs.* Drain Com'r, 56 Mich. 634.
4 Lane *vs.* Burnap, 39 Mich. 736.
5 Gillett *vs.* McLaughlin, 37 N. W. 551.

not be out of place. If any of you have had occasion to work with it, you must have felt that it was open to criticism in many places.

If we must have farmers for drain commissioners, and they of all others should be the best qualified to make an assessment of benefits, some provision should be made whereby they can employ counsel. It is folly to expect that an election to office will of itself endow a man with the skill that is to be acquired only by long familiarity with law forms.

It is also a serious question whether or not the township drain law is not an evil. It seems as though one man could do the work for less than fifteen or twenty would, to say nothing of the loss of time, trouble, and mistakes involved in "breaking in" so many.

Again, it is a mistake that the county or township at large are in no way interested in, or responsible for, the drain tax. The result is that public officers take no interest in seeing that the commissioner's proceedings are regular, nor do they look very closely into his accounts. The responsibility of the public for the drain tax ought to be as great as for any other tax; and the public would then provide some means of seeing that it was properly levied and collected.

The powers of the commissioner should be more distinctly defined than at present, as I have before pointed out. The provision for the assessment of benefits should be so modified that it could not be made until after the sale of the drain. Judge Sherwood has expressed grave doubts as to the constitutionality of the present provision.[1]

The provision for vacating or abandoning a drain are a curiosity, and if any one can tell what it means, his acumen would be indeed keen.

The drain law, in fact, is a heterogeneous mass of provisions passed by a legislature who seemed to have very little idea of legal rights or forms, and thought that private property and private rights could be invaded without any other process than the mere *fiat* of a session law.

Its practical workings, where lands are owned by non-residents, is about the same as the old law of 1839. The unfortunate resident who is forced to have a drain, "can enter with his servants, teams, carriages and other necessary implements," and proceed to dig the drain at his own expense; for a drain tax, assessed against non-resident land, is very rarely paid and could be still more rarely enforced.

WILLIS BALDWIN.

1 Kinne *vs.* Bare, N. W.

IRRIGATION IN COLORADO.

IRRIGATION is not a new question to the human race, but to the English speaking people and their ancestors, living in countries whose natural rainfall is sufficient to the practice of a successful agriculture, irrigation has not been a necessity, and we, as a people, now meet this problem of irrigation without acquired experience.

Arid lands are not the only lands benefited by irrigation. In countries having an abundant rainfall but suffering an occasional drouth in heat of summer, irrigation furnishes water to the thirsty crops, and even in the most favorable years increases the products of the farm.

That irrigation is beneficial in countries of abundant rainfall, witness the valley of the Po, the garden of Europe. That valley has a rainfall greater than that of Michigan, yet so apparent are the benefits of irrigation, that the irrigated area has doubled in the last thirty years.

Agriculture cannot generally be successfully followed in regions where the rainfall is less than twenty inches. In the United States the line of twenty inches rainfall passes south through central Dakota, western Nebraska, Kansas and Texas. Except for a little area on the Pacific coast, all the region west of the above named line has a rainfall so small as to make ordinary agriculture precarious. The eastern limit of this arid area will be put at 98° by the United States Senate committee on irrigation, making this arid area include about one-third part of the United States—and this by no means the least fertile part, as some of the finest crops in the world are raised here in the heart of the American desert.

EXTENT OF IRRIGATION IN COLORADO.

There are now some 1100 canals in Colorado. The primary canals, meaning by this all those which take water from the river, irrespective of size, measure over 6000 miles. The secondary canals it is impossible to estimate, but as these include all the branches of the primary canals, some of which are forty feet wide on the bottom, it is evident the mileage is very great.

In the short time since Colorado began to irrigate, some 4550 square miles or 3,000,000 acres have been brought "under ditch;" of this amount, taking the State as a whole, probably not far from one-third, or one million acres, is actually irrigated. Considering the fact that Colorado's irrigation development dates back only fifteen years, this is a creditable illus-

tration of the activity of the western people, and the way they are taking hold of the problem of irrigation. In France there were in 1887 only 400,000 acres irrigated. In the valley of the Po there were, in 1882, after six hundred years development, 3,000,000 acres irrigated.

Some canals date back to 1859, more to 1864, but until the Greeley colony settled on the plains in 1871, it was not generally believed that the mesa or uplands were worth anything. There had been a few ditches successfully watering the highlands as long ago as 1864, but these cases were not generally known. The first ditches were small. One ten feet wide on the bottom was an exception. The large ones are all of recent date, most of them having been built since 1880. Some of these have cost hundreds of thousands of dollars, and water thousands of acres of land, and are forty, fifty, or a hundred miles in length.

At no time has there been more activity in ditch construction than at present. The valleys of the Platte and its tributaries from Denver to the mouth of the Cache a la Poudre were first developed, and are the oldest agricultural regions of the State. As mentioned before, the town of Greeley lies in this region. The lower Platte has developed little on account of shortage of water. To supply the area already developed, and to furnish water to the lands rapidly being brought under cultivation, reservoirs for the storage of water are being built in the mountains and on the plains by individuals and by companies. These reservoirs vary in size from 300 acres to small ones intended for a single farm. Reservoirs are destined to play an important part in the future of the irrigation economy of the whole West.

The first problem of the irrigation engineer ought to be that of the water supply. By the laws of the arid region, the first ditches have the prior right, hence any new ditch must get its supply after the rest are satisfied. Some ditches costing hundreds of thousands of dollars have apparently been built without much regard to the supply of water.

CANALS.

These are generally built through lands in advance of all settlement. The projector often buys of the State large blocks of land which, when watered, become very valuable. Though most of the canals are of this character, settlers sometimes, in self-defense, combine to take out a canal for new lands, starting the head above that of the first or old canal, or

they may run a new ditch parallel to the one whose charges they consider exorbitant.

HEADS.

Where the lands are chosen with a view to bringing under cultivation by means of water, it is necessary to first find a suitable location for the head works. A favorable site is all important, so that a headgate and dam may be built without too great expense and with little risk of washouts or of being separated from the stream by sand deposits. Account must also be made of the effect the site will have upon the route below; whether it leads to a favorable course above the bluffs to the objective table land or not. The selection of a site is less important on streams with a rapid fall and firm bottom, than in sandy ones, like the Platte or the Arkansas.

The site selected, the line is then run from the site of the headgate and with the fall which the engineer desires to give, which will vary according to the size of the ditch and the character of the soil, he should not lose sight of the fact that the ditch is to be maintained and that the cost of maintenance depends much upon his judgment in selecting a route.

Sand, extensive fields of which line both the Arkansas and the Platte Rivers, it is always desirable to avoid, as it drifts into the ditches in such quantities as to cause a heavy yearly expense for cleaning, and the loss by percolation or seepage of water is very great.

Flumes and artificial embankments are also to be avoided, if possible, as the former are a constant source of expense in money, water and care, and the latter are subject to the burrowing of moles. The flumes and embankments cause more anxiety to every ditch manager than all the rest of the canal together. If either flume or embankment must be had, then it should be built with proper care, for a break in the busy season means the loss of thousand of dollars to those taking water, possibly the loss of the entire season's work.

Floods are to be provided for, if possible. The plains shed rain like a roof and one learns to respect every insignificant "draw." As an instance I may mention the flume across Horse Creek, on the Henry canal, as shown in one of the smallest photographs accompanying this paper. When I visited it in April there was no water above the sand. The flume, on pile bents 16 feet apart, was high enough in most places to drive a carriage under, yet a sudden storm on the plains in June made this stream a torrent, broke the piles like pipe-stems and wrecked the flume.

GRADE.

The fall needs to be sufficient to give a current with a velocity which will prevent the growth of aquatic plants tending to choke the ditch, but not so great as to seriously scour the channel or be unmanageable in high water. The velocity desired is from two to four feet per second, depending upon the size as well as the grade of the ditch; greater grades may be used in smaller ditches than in large ones. The following table gives the grades of most of the large canals. The tendency, at present, seems to be to lessen these grades somewhat.

Name of Canal.	Grade.	Carrying Capacity.	Width, Feet.	Length, Miles.
Larimer and Weld	2.37	720	30-18	64
High Line Canal	1.76	1184	40	85
Rio Grande	2.45	.....	.....	.....
Citizens	3.0 to 0.5	.....	40	.....
Uncompahgre	3.38	725	.....	32
Henry	2.11, 1.58	.....	30	112
Grand River	1.82	.....	.....	.....
Fort Morgan	2.6, 1.57	340	30	28
Springdale	3.6	115	20	13
Pawnee	1.67	415	35	30
Schneider	3.2	.....	14	.....
Platte and Beaver	2.56, 2	313	30	25
Platte and Beaver Supply	2.11	.....	26	.....
Weldon Valley	2.5	300	20	16
Kiowa and Bijou	1.5	.....	40	50
Prairie	2.7	.....	20	26
Lariat	10	.....	20	4
North Poudre	2.11	.....	.....	.....
San Luis	2.64	.....	34	50
Empire	1.67	.....	60	35
Bessemer	1.25 to 3	.....	24	20+
Dolores, No. 2	2.56	.....	25	6
Amity	1.06 2.11	.....	35	.....

CROSS SECTION.

The cross section of a ditch is trapezoidal, wide in proportion to depth. On account of loss by evaporation, it would seem better practice to build the canals narrower and deeper than is the usual practice. The side slopes in natural earth are 1 or 1½ to 1; occasionally, as in the Del Norte and the Citizen's canal, 2 or 3 to 1. In artificial embankments the slope is 1½ or 2 to 1. The excavated earth is generally put

into an embankment on the lower side of the canal. The top is brought to grade with the intention of making the embankment increase the carrying capacity of the ditch. Practice varies in the use of a berm. When used, four or five feet is sufficient. The movement of earth is done with "slussers," or with wheeled scrapers, at a prevailing cost of 9 or 10 cents per cubic yard.

In several localities ditching machines are used for constructing the laterals. The Monte Vista canal company, as well as that of the Grand River, use a steam dredge for cleaning and extending the ditches. These were adapted to the work and were introduced by W. H. Graves, C. E., the engineer of these enterprises. These are said to excavate at a cost of 3 cents per cubic yard.

HEAD WORKS.

These consist of the dam, waste gate, sand chute, and headgates. The dams are as various as their conditions. They do not generally act as a dam proper, but as a dam for diversion of water. On rocky bottoms it often consists of a few rows of loose boulders sometimes filled in with brush. In the sandy streams of the plains they are all deflecting dams only. In many cases they are simply sand embankments, thrown up with a scraper, running obliquely up the stream, so as to have no pressure to withstand. Every flood washes them out, but they are easily rebuilt. One photograph shows the dam of the Platte and Beaver canal near Fort Morgan, which is the only permanent structure worthy the name on the lower Platte. It consists of a double row of piles eight feet apart, driven at least one or two feet into bed rock, which is 8 to 14 feet below the surface. Each row of piles is sheet piled, each plank being driven to bed rock. The upper piles are 1½ feet above low water. The space between the piles was excavated for three feet and filled with one foot of brush, and two of stone. The dam is 832 feet long and the headgate cost $12,000.

The Platte, it may be said, is a very peculiar river, dry at one point and a little way below a lively stream of water. The sands are generally saturated with water. A dam like that of the Platte and Beaver is intended to intercept the underground flow and bring it into the canal. In the mountains some solid dams are built, as the photograph of the one on the Big Thompson shows.

SAND CHUTES.

In many places the sand is carried with the current. It is not in suspension, but the current rolls it along the river bottom, where it soon fills the headgates and upper portions of the canal. Many preventive devices are tried, but none, so far, are completely successful. The one that appears to do best work, is to keep a flash board below the headgates proper. This causes the sand to fall in front of the gates, and when the deposit has acquired a certain depth it is drawn out by opening the waste gates.

THE WASTE GATES.

The waste gates, if any, are generally supplied with flash boards. Several photographs show them in connection with the dam.

HEADGATES.

The headgate forms, in general, the most important and expensive structure of the ditch. It is built always of wood, though the time is not far distant when we shall follow the example of Italy and build of the stone which is so abundant everywhere. The headgate consists of piles, surmounted by heavy timber, securely braced to withstand the pressure of the water. Aprons should be used in all such structures, though sheet piling is frequently found instead. The gates vary from 3 to 6 feet, clear opening. A good type is that of the Del Norte canal in the large photograph.

FLUMES.

Examples of flumes in the High Line canal in Platte Canyon, 2640 feet long and 28 feet wide, 7 feet deep, grade 5.28 feet to the mile. Also one of similar construction on the same canal over Plum Creek. The latter is some 1800 feet long. It consists of bents of eight piles each 18 feet apart, the piles 6 feet, 3 inches apart. Mudsills 12x12 inches and 48 feet long made of three pieces. The posts are 10x10 inches, mortised into sill and cap. The piles were mortised into the sills, but now the practice is to drift bolt entirely, that costing less and the pile lasting longer. Other views show the excellent Fort Morgan flume nearly half a mile long, the flume near Lamar, one on the Henry canal, etc.

A blue print of the Del Norte, now called the Rio Grande canal system, is inclosed as an illustration of a canal system. This is probably the largest canal in the United States. Starting near the town of Del Norte, at the point where the

Rio Grande enters the San Luis valley, it skirts the foot hills and passes out into the valley. Its course is nearly at right angles to the river, as the river is in the highest part of the valley. It secures its supply of water by damming a branch of the Rio Grande and turning the water down its headgates. A screen made of piles and some distance in front of the headgate, keeps out all floating timber.

The headgate consists of ten gates raised by a screw worked by a wrench. The canal at the head is 65 feet on the bottom and carries 5½ feet of water. The side slopes are 3 to 1, making the width at the water line 98 feet. Four miles from the head it is bifurcated, the large branch being 42, the small one 38 feet wide. Each of these branches gives rise to various laterals, which have been built by the company. These are generally 10 or more feet wide. The length of the main canal is about 50 miles, of the laterals 150 miles. A study of the map will show the unusual character of the country, which is very uniform and slopes from the river. The ditches follow the section lines entirely. All the region between the two branches may be watered from either branch. As an illustration of the evenness of the country, it may be mentioned that one canal runs 26 miles on a section line.

Many other points regarding irrigation and construction it is desirable to mention but lack of time and space prevents. Had it been possible to have had them drawn in time, detailed plans now in my note book of dams, headgates and flumes would have been sent you. L. G. CARPENTER.

Prof. Greene.—"Two or three matters occurred to me as the paper was being read. There is no doubt that the farmers of the West wish the matters of irrigation should go as far as possible, but I think that a great many of these constructions must be of a very temporary nature. It seems to me that though very satisfactory now, there will be in the future considerable expense for repairs. Of course it is to be said that if they were built of stone the work could not have been carried to so great an extent, and there is no doubt structures in the future will be more permanently constructed.

"Another point is in reference to the right of riparian owners. It would seem that where irrigation laws are in force it may happen that one party may have the right to take all of the water from a stream and appropriate it to his own use. That is quite different from the rights of riparian owners in this State and those living near the head waters of a stream would have the best chance."

Mr. Forster.—"A good deal of this is hinged in the mining laws."

Mr. Hodgman.—"It might seem at first thought that the question of irrigation is of little interest to us in Michigan, but to me it has an interest in two ways. First, the great irrigation works of the West are already furnishing employment to some of the members of our society, and are opening out a wide field for the employment of engineelrs in the future Second, I have great interest in whatever will tend to make more prosperous the people in our own State, and I am very confident that the conditions now exist which will make it profitable to irrigate a very considerable amount of our lands right here in Michigan. We are subject to periodical drouths by which our crops are greatly lessened and many times ruined entirely. There is a great deal of land in Michigan so situated with reference to the streams, that it can be easily and cheaply irrigated. Take, for instance, the land in the valley of the Kalamazoo in my own county. There is a tract of land from half a mile to a mile or more wide, extending for from 25 to 30 miles, in that county, which could readily take the water from the river for irrigating purposes. In addition there are numerous tributaries, small spring streams, which never fail, emptying into the river all along the valley. These streams are admirably situated for purposes of irrigation, and I believe that in many cases the small expense required to turn them so as to utilize the water would, in some of our dry seasons, be repaid by a single crop. I had opportunity a few years since to become quite familiar with such small irrigation works as would be required in the case I have mentioned, and it may be of interest to the members of the society to know a little more of the details of how the work is done. The parties wishing to irrigate their lands go up stream to a point sufficiently high to get the necessary fall. How far that will be depends on the fall in the stream and the hight of the valley above it. Having found this point, a ditch is started down stream and gradually leading away from the main stream. The ditch follows very nearly on the level contour line, only dropping enough below it to give the necessary flow to the water. For a small ditch which is only expected to water two or three small farms, the line is marked out by stakes stuck along at short irregular distances, and then when the ground admits of it, a back furrow or ridge is turned up with the plow. Then on the uphill side of the back furrow the ditch is cleared out and opened with the spade or shovel; the dirt which is taken out being used to build up the banks. The

water in the ditch is above the surface of the land adjoining, held there by the banks thrown up. On the downhill side of the ditch is the furrow made by the plow in turning up the back furrow. This is cleaned out to be used as a channel for the water to run in when required. The land to be irrigated, after being sown or planted, has little furrows made all over it running up and down the slope from the margin of the ditch. These are made by a tool made something like a corn marker, with the teeth about a foot apart. It is made from a small log from 3 to 10 feet long, according as the surface is rough or not, with pegs driven in to make the furrows. The fields after being furrowed, resemble a field just drilled into wheat. When the land is to be watered, two little dams made of a few shovels of dirt are thrown across the plow furrow, which parallels the ditch, at a distance of 2 to 10 rods apart. Then an opening is made in the bank of the ditch; the furrow between the dams fills with water and overflows, the water running down the little furrows or drill marks. A man keeps along with the water as it flows and removes lumps of dirt or any other obstructions which may prevent the water from finding its way down any of the little furrows. When the ground is sufficiently watered, the opening in the ditch is closed and another strip watered in the same way until all is done. I have crossed fields in Utah that had been irrigated, where I would sink nearly to my knees in the mud at every step. In many cases these irrigating ditches furnish the farmer all the water he has to use, and the man and his wife, his horse and his pig all drink from the same ditch. I had sometimes to do the same or go without water."

Mr. June.—"This matter of irrigation in Michigan comes home to us in Osceola county, where we have a good deal of land that might be irrigated that is nearly worthless without it. One man irrigated a patch of potatoes last year and got a big crop, when all the rest were nearly a failure. Sylvan township is somewhat flat and it is the only township that has done anything with drainage, let alone irrigation. I should say that about five miles of ditch have been put in for the purpose of draining land rather than wetting it. The water of that ditch could all be used profitably, and I see that this may amount to a good deal here, as well as in the West."

Prof. Greene.—"It is suggested that irrigation might be a good thing for some parts of Michigan.

"You cannot irrigate a country unless you have water. And you cannot get water unless you get rainfall, and if the rainfall becomes so little that crops will not grow that is the

end of it. In the West the water comes from the accumulation of the snow on the mountains, enough to carry them through the summer, and yet sometimes there is not enough to satisfy the country. We have seen statements in regard to the subsidence of the level of the great lakes, that vessels carrying a certain draught could not pass. Attention has also been called to the fact that the smaller lakes have been going down. I have been interested somewhat with regard to my water supply, so I have collected some facts which I have put on paper in the form of a diagram. Some notes as to rainfall are taken by the State Board of Health.

		At Ann Arbor.
In 1877	35.25	
In 1878	38.06	
In 1879	36.35	
In 1880	41.88	
In 1881	43.21	40.36
In 1882	37.25	36.22
In 1883	40.91	35.27
In 1884	37.02	.....
In 1885	35.82	35.14
In 1886	32.16	20.6
In 1887	.....	28.65
In 1888	.....	26.52
In 1889	.....	23.34

"Ann Arbor lies on a gravel soil which rapidly absorbs water. Trees put out their leaves and grow, and in the latter part of the summer they suffer from drouth. But all this don't bring the rainfall.

"If that continued through a series of years, irrigation would do no good, for you would have no rainfall. If we could have our rainfall in the summer instead of in the winter, as we have it now, something might be accomplished.

"You can't supply a place with water where you don't have rainfall enough to supply the demand. I think that the precipitation will increase, and I expect to get back to the time when we will have plenty of water."

Mr. Forster.—"It seems to be on the increase."

Mr. Hodgman.—"I did not wish to be understood that all parts of Michigan can be irrigated, or that it would pay to irrigate everywhere if it could be done. But I am very sure there are many very considerable tracts of land in the State that can be profitably irrigated from spring streams that are no more uncertain in their supply of water than are the streams of the West."

Prof. Carpenter.—"In connection with Prof. Greene's remarks, I would say that I have just come from a State where the condition has been the reverse of what they have here. In New York they have had 72 inches of rain since last May. While our farmers have suffered from drouth, they have suffered from wet. In places the streams have left their beds and run across fields and roads, cutting channels and doing great damage."

Mr. Hodgman.—"That is what I would call running irrigation into the ground."

Prof. Carpenter.—"We have three wells at the college and during the dry time it was thought they would not hold out; but they have. This indicates a head somewhere not affected by the drouth."

Mr. Wells.—"In Wexford county is a tract known as Briar Hills which lies about 1200 feet above Lake Michigan. Below them are agricultural lands lying about 500 feet above the lake, and still further west another tract of about 200 feet elevation. In the Briar Hills many spring brooks take their rise and have cut deep channels in their way to the lake. A year ago this summer, when it was a very dry season, I noticed that the farmers' crops were parching in the sun and these streams running as full as ever. If the water had been utilized it would have saved the crops for some parts of Michigan."

. . . THE . . .

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F. HODGMAN,

Sec. Mich. Eng. Society,

CLIMAX, MICH.

AN INDIAN LEGEND.

THIS legend was recited by David Shapanagon, an Indian living at Grayling, Michigan. He speaks broken English, has learned but very few words, and is therefore obliged to make the same word do duty for several different meanings. He is about 70 years old, and has considerable dramatic power. He says that the legend was taught to him when he was a child; that he has recited it many times before large audiences of Indians, and sometimes has received a pony as prize for the best story. He believes it to be true. The writer heard of the legend through Mr. A. B. Valentine, formerly surveyor of Montmorency County, Michigan. Mr. Valentine speaks Chippewa, and had hunted with Shapanagon, and had heard him recite the legend. Mr. Valentine told fragments of it to the writer and referred him to Shapanagon. The writer visited Shapanagon about four years ago, and heard the legend once. Its recital occupied about two hours. It has been written from memory. The salient points are all preserved, but the details are very deficient; this is especially the case in the description of the storming of the Saugee village and the massacre of the inhabitants; here the recital was especially animated. The orator was very dramatic and graceful, but so much depended upon the action and pantomime that all the writer can remember seems very meager. When he says his "*grandfather*" settled in the country of the Saugees, he probably means his ancestors. When he uses the term "*five hundred years*," he probably means a long time; also, when he speaks of "*five thousand men*," he means a great many, a host, a multitude. When he says that "*the chief spoke an hour*," he means that he made a long speech. It is probable that he used these words, because he knew of no other in English, but if he had spoken in his own language he would have given different shades of meaning.

Five hundred years ago the Chippewa Indians lived at the Straits of Mackinac. They had all the land on the other side of the Straits up to Lake Superior; on this side their land came to the Au Sable and Manistee Rivers—(in one place these two rivers came close together, not a mile apart; this narrow place was the boundary). Their largest city, where their head chief lived, was at the Straits of Mackinac. The Saugee Indians lived on the south side of the river, around Saginaw Bay. Saginaw means Sow-gee-naw, or the country of the Saugees. Their largest city, where the head chief lived, was near where Sebawaing is now; they had another smaller city where the three rivers meet at Midland. If any of the Sau-

gees went hunting on the north side of the Sable or Manistee Rivers, then the Chippewas could kill them and scalp them, and there would be no war. If the Chippewas went hunting on the south side of these rivers, and the Saugees could catch them, then they could kill them and there would be no war. One autumn, after the hunting was over, the Chippewas came back to Mackinac to stay all winter. One family did not come, so their relations told the Chippewa chief. He asked all the men that had been out hunting, "Have you seen this family?"

One man said, "Yes."

The chief said, "Where were they?"

The man said, "They were in a camp close by the Sable River, but on their own side."

The chief said, "When did you see them?"

The man said, "Five days before I started to come here."

Then the chief said, "I want you to take twenty men, all swift, and go and find out what has become of this family. If the man is hurt, or his family is hurt, then you help them come here. I make you chief of the twenty men."

Then this man got twenty other men, all swift. They went through the woods, because it was so near winter that they thought there would be wind and rain on the lake, but there was no wind or rain, so they went fast and came to the place where the man's camp had been. The man and his family were gone. He had one kettle made of clay and one stone ax; these were gone too. There was a heap of ashes where his camp fire had been. Then the chief said to one man, "You stay here and cook." He said to the other men, "Stand in a ring around the camp, with your backs in and your faces out; then every man go in the way he is looking. Look on the ground, logs, trees, bushes, in the water, everywhere, to find this family. When you get farther apart, go to the right hand until you meet the man on that side, then go to the left hand until you meet the man on that side, then go back to your own place and go on a little farther, and do so again so that you will look under every tree in the woods. When it gets dark, lie down right where you are, so as to begin hunting in the morning, for we must find this family before the snow covers up their tracks."

That night it rained very hard, because it had not rained any before; all the leaves hung straight down, and the water ran down both sides. In the morning the cook was pretty wet; he walked around, pretty soon he saw that the ashes had sunk down in the middle. What was that! That

must mean something! He went out into the woods and called. By and by a man answered him and said, "What do you want?" Then the cook man said, "I want all the men to come back, I have found something." So one went to the right and told that man, and the other went to the left and told that man, and they told the next man, and so all of them came back to the camp. Then the chief man asked the cook man what he wanted. He said, "Have all the men stand around the ashes, this time with their faces in." Then he showed the chief where the rain had made the ashes sink down in the middle. The chief said, "What is this?" All the men said, "I don't know." The chief told the men to dig. They found that the ground had been dug up before. Pretty soon they found a man's hand; they pulled him out. Next they found the woman, and in the bottom the two children; all of them had been tomahawked and scalped. The chief said, "All of you look and remember what you see, so that we can tell when we get home." Then they got all of the bodies straight, and put clean birch bark around them, and dug a grave for them, and after it was filled up they put four sticks at the corners. Then they started home. The rain turned to snow, but all the men were swift and could go a long time without eating, so they got home. Then all the people asked them, "What have you found?" The men said, "We are hungry." The head chief said, "Give them something to eat." After they had eaten all the people asked them again, "What have you found?" And the men said, "We will smoke." Then the head chief said, "Bring them pipes and tobacco." After they had smoked, the head chief said, "Sit down in a ring, and let your chief man tell us what you have found." So they sat down in a ring, just behind them the men, and farther back the women and children. Then the chief man told the head chief all that they had found, and the other men said it was true. Then the women began to cry. The young men said, "The Saugees did it, we will go and kill them," and they waved their tomahawks and jumped up and down and patted their hands on their mouths and whooped. After a long time the head chief said, "Listen, I don't know who killed this family. It may have been the Algonquins; it may have been the Winnebagos; maybe it was the Saugees; I don't know, we will go and find out." So the young men waited.

* * * * * * * * * * * *

When the spring came, the Chippewa chief told five thousand of his men to get ready and go with him to see if the Sau-

gees killed that family. So they brought their canoes and put two side by side, and covered them over with bark. Then in the middle they had a pole about ten feet high; on the top of this pole they placed a bunch of feathers—some red and some black. There were more than five hundred such canoes, and the chief had the largest one. Some men would sit in the canoes and paddle; some more would stand up on the bark decks and dance. They had feathers in their heads and paint on their faces, and did not wear any clothes except around their waists. All of them had tomahawks and bows and arrows. They did not start until there was no wind, then all of the canoes kept together, and the men jumped and danced and whooped all the time. When the wind blew they went on shore and waited until it stopped. So it took a long time, three weeks, to get to the Saugee city. When they came in sight, a Saugee man saw them and went to the Saugee chief and told him that the lake was getting black. Then the Saugee chief went to the bank of the lake; he heard the whooping and saw the men dancing on the bark decks of the canoes. He told all the Saugee men to come to the bank of the lake, for the Chippewas were coming and wanted something. So when the Chippewa boats got near the shore all the Saugee men stood on the bank. Then the Saugee chief said:—

"What do you want?"

The Chippewa chief said: "We want to come on shore and talk with you."

Then the Saugee chief told the Chippewa chief and his men to land. He made a line that was a little way back in the woods and parallel to the shore. He told the Chippewa chief that his men could stay between that line and the water. So the Chippewas came on shore and drew their canoes up on the sand. Then the Chippewa chief said to the Saugee chief: "We want to eat." So the Saugee chief had plenty of fish and venison and corn brought to the Chippewas, and they ate all they wanted. Then the Chippewa chief said, "Let us smoke." So all of the Saugees sat down on one side of the line and the Chippewas on the other side facing them. The two chiefs were at the upper end of the line facing each other; next to them were the older men; then came the younger men, so that the youngest Chippewa and the youngest Saugee sat facing each other at the lower end of the line. Then the Saugee chief had the women bring him a hard, dry piece of elm wood, and a round hickory stick like a cane. One end was rounded off so that its point was smooth and hard. In the block of elm wood there was a small hole like a cup. The

chiefs stood the hickory stick in this hole; then they took some punk that they got from a rotten log and picked it up fine and put it in the hole around the end of the stick. Then the chiefs whirled the stick by rubbing it between their hands, so. There was a stone on top of the stick to hold it down. Pretty soon the lower end of the stick began to smoke; then the punk caught on fire. This was a good fire because it was new. No one had a chance to put anything bad in it, or say any devil words when they were making it. Then the chiefs lighted a large pipe, the Chippewa chief took one mouthful of smoke and handed the pipe to the Saugee chief; he took a mouthful and handed it back to a Chippewa man, and so the pipe went backwards and forwards down to the end of the line. Then every man took his own pipe and smoked and laughed and talked about common things. Sometimes a Chippewa would tell a story and the Saugee who sat opposite to him would laugh; then the Saugee would tell a story and may be the Chippewa would laugh, but the Chippewa said nothing about the family that were murdered. After one hour, the Chippewa chief stood up and said: "We came to talk to you about something." Then he told the Saugee chief all about the family that had been killed and scalped, and said: "We have come to ask you if any of your men did this." Then the Saugee chief said: "I feel badly. I do not know who killed this family. Maybe there are some bad Saugees who know about this; I will go and see." So the Saugee chief called all his people together and asked them if anyone knew who killed this family. Some of them got afraid and told who did it. There were six of the murderers; they thought they had buried the bodies so that no one would ever find them, but they showed the scalps to some of the Saugees, and these men told the chief. So the Saugee chief came back and said to the Chippewa chief: "We have found the men that killed this family. Now, what do you want?" The Chippewa chief said, "Give them to us." So the Saugee chief had these six men tied so they could not move; then he had them laid on the ground before the Chippewa chief. These men felt pretty badly, but they did not say anything. The Chippewas tied them to three stakes, two on each stake, back to back. Then the relations of the murdered family came first with their flint knives, and each cut off a piece of ear or nose or cheek. Then all the other Chippewa men came and each cut off a piece. Finally when the Saugee murderers were almost dead, the Chippewa chief came and scalped them and had the scalps for himself. Then the Chippewas piled wood around the dead bodies as they hung on the

stakes, and burned them up. All the time the Saugees stood back a little way and looked on. They felt pretty badly but were afraid to do anything, because there were five thousand of the Chippewas, and each man had his tomahawk. The relations of the men that were burned up saw it too, and they felt the worst of anyone. They were afraid to say anything out loud, but said low to each other: "When we get a chance we will kill some Chippewas and scalp them." Then the Chippewa chief said to the Saugee chief: "I want to say something more to you. You have seen what we have done, and know what kind of men we are. If you want to fight with us next year, we will fight with you then; if you want to fight with us next month, we will fight with you then; if you want to fight with us now, *lift up your tomahawk*," but the Saugee chief let his tomahawk hang down. Then the Chippewa chief said: "If you don't want to fight with us, we will get in our canoes and go home. We will hunt on the north side of the rivers and you may hunt on the south side as we did before. We will bury the tomahawk, so, with the handle sticking up out of the ground. Then, if your people kill any more of our people, we can *take it up quickly*. We will go back this one time. If we ever come again, *we will stay*." So the Chippewas got in their canoes and went home. All that year they hunted and fished and nobody was killed.

* * * * * * * * * * * *

The next year a family of Chippewas had their camp on the north bank of the Sable River. A Saugee saw it, who was a relation of the six Saugees who had been burned. He told some more of his relations; they talked together, but did not let the Saugee chief hear them. They said: "We will kill this family of Chippewas, and no one will know who did it." So they killed them and scalped them and hid the bodies in a swamp. When the time came for the family to come home and they did not, the Chippewa chief sent men as before to see what was the matter. After a long hunt they found the bodies and came back and told all the people about it. Then the young men said, "The Saugees did this, let us go now and kill them and scalp them." The Chippewa chief said: "Wait until we are ready, so that we can kill them all." But the young men said, "We are ready now, if the chief is afraid to go with us, he can stay, and we will have another chief." Then the chief called all the men together, and he stood up and talked one hour to them. He said: "We must kill all of the Saugees. All of our men must go. It will take all summer. We must leave

something for our women and children to eat while we are gone. We want some dried fish and venison to take with us. We want more canoes; we want more tomahawks and arrows. It will take one year to get these things. If you go now, there will be ice in the water and snow on the ground before you get there. If you have had nothing to eat on the road you will be weak, and the Saugees will be stronger than you are. I am not afraid. You saw me when we went there before, and took the six men and burned them. You heard what I said to the Saugee chief. If any young man thinks he is braver than I, let him stand up and speak." The young men were ashamed and did not say anything. A good many of the old men stood up and spoke, and at last all thought the chief's way was best. So the chief told all the hunters to dry and keep half of all the venison and fish that they got the next year. He told the men that made canoes, and the men that made arrows and tomahawks, to make twice as many as before, and save one-half; and so about everything that was made. Every Chippewa, man and woman, had to do twice as much that year as ever before. The chief told all the men and women and children not to tell any other Indians what they were doing. So if a Winnebago came to the Chippewas and asked: "What do you make so many canoes for?" the Chippewas would say: "Oh, maybe next year we will go to Lake Superior and fish." So for one year the Chippewas got ready and the Saugees thought that nothing would happen to them. Finally, when all was ready, the Chippewa chief took five thousand men and started. One-half of them went in canoes, and one-half went on foot through the woods. Those that went in canoes were going to Sebawaing, and those that went through the woods were going to Midland. The head chief went in a canoe. He made another man chief of the men that went on foot. He told this chief to get to Midland in just twenty days and begin killing the Saugees at day-light in the morning, He told this chief to have some swift runners go ahead of his men, and if there were any hunters camped in the woods, to kill them, so that they would not run home and tell the Saugees that the Chippewas were coming. He had two canoes, with swift paddlers, go ahead of his other canoes, so as to catch and kill any fishermen, and not let them get away and tell the Saugees that the Chippewas were coming. The men in the canoes went slowly, so as to get to Sebawaing just the same morning that the other men got to Midland. When the Chippewas got to Sebawaing, they found the Saugees all asleep; they got all around the village, and at daylight they all whooped and ran

in. The Saugees did not know what to do. The Chippewas killed them—men, women and children. The Chippewas set fire to the houses. The dogs barked and the Chippewas killed them too. Some of the Saugee men got away and ran towards Midland; half way there they met other men running away from Midland; then all ran towards where Port Huron is now. The Chippewas followed them; if a Saugee man got tired the Chippewas killed him and scalped him. About one hundred Saugee men got to Port Huron and crossed the river on logs or swam. The Chippewas did not follow them any farther and never heard of them again. All of the Saugee women and children were killed, and their dogs and pigs and ponies. When the Chippewas got back to Sebawaing the chief called them all together and said: "This is a good land and there is no one alive in it; if any of you want to stay here you can." So a good many of them stayed, and among them was my grandfather. He and his children always lived there afterwards.

E. S. WHEELER.

A MANUAL OF LAND SURVEYING.

OWOSSO, MICH., Dec. 16, 1889.

MR. HODGMAN, *Sec. Mich. Eng. Society.*

DEAR SIR:—Enclosed please find draft for your bill short bank exchange. The Manual of Land Surveying received from you some time since, is a splendid book, worth twice its price. Yours truly,

H. C. MAIN.

Shiawassee County Surveyor.

F. HODGMAN, Climax, Mich.

TRUE EXTERIOR BOUNDARY OF THE TOWNSHIP.

A CONTRIBUTOR to our exchange from the Illinois Society of Engineers and Surveyors, for 1888, advances ideas that I can not endorse.

After a vast expenditure of ink, and some erudition, he comes to the conclusion "*that the boundary, as modified by subdivisional survey lines and corners, is to be regarded as the true boundary line of the township.*"

This interpretation would ignore the following facts in relation to this question:—

1. The principle universally recognized in all the public surveys, that consecutive corners—except in the case of meanders—are to be joined by right lines.

2. That all subdivisional lines of any legal division, are controlled and determined by the boundary lines of such division.

3. That the closing of subdivisional lines at points not in the boundary of the legal division thus subdivided, is anomalous to the fixing of the interior corners; and therefore not subject to the same law.

4. That the closing corner is always described and returned by the deputy-surveyor as being on the boundary line.

5. It ignores the ruling of the Commissioners of the General Land office, in a particular case, "that the township line is also the boundary line of those sections immediately south of it; and that the setting of a corner beyond or short of it does in no way change the place of the boundary line."

6. This interpretation of the law would produce a conflict of interest.

The possessor, say on the north of the boundary line, by this ruling, holds to the original boundary; while the possessor on the south, by the same law, holds to the modified line—thus producing a conflict of interest when the subdivisional lines extend across the boundary, and thereby perpetuating and intensifying the difficulty, the law fixing the interior corners, was designed to obviate.

The anomalous character of this case, as compared with that of an interior corner, is seen in the fact that in the boundary two lines may occur, thereby producing the conflict of interest referred to, while in the interior of the township no such case can occur.

It is evident that the case under consideration was never thought of, much less was it provided for by the law-makers,

when they provided that the lines and corners, as returned, should be regarded as the true lines and corners. As a consequence, to consider the law as applying to this case, would be a stultification of the law, an act that courts and law-makers are not often guilty of.

As before shown, the ruling of our Illinois friend would give to each of the two contestants the same legal right to the same piece of land.

Now, when we can find an intelligent court in the United States that will eject either of these parties to make room for the other, we will admit that there is some merit in the logic of our Illinois friend.

Until that time come, I do not know what can be done with a corner that has been set beyond or short of the line, more than to use it as a means of finding where the section line intersects the town line, at which place the county surveyor may proceed to plant a *new corner*, though, perhaps, he may not disturb the old one. H. C. PEARSON.

BOTH'S SECTION-LINER.

CORNELL UNIVERSITY,
College of Civil Engineering.
ITHACA, N. Y., March 16, 1890.

A. C. BOTH, *Civil Engineer.*

DEAR SIR:—This college of Cornell University has had in use, or in its collection of special instruments, every variety of "Section-Liners" it has been able to procure.

I have no hesitation in saying that the one purchased of you a few weeks ago is the best one yet brought to my notice, and is simple, reliable and satisfactory for its purposes.

The use of all other Section-Liners has been abandoned here, and yours is exclusively employed. I am Sincerely Yours,

E. A. FUERTES.

Director Coll. Civil Engineering.

See Advertisement, page 29.

HARDENING AND TEMPERING OF STEEL.

MR. HODGMAN, secretary, came to me last Friday, and wanted to know if I could not read a paper on Steel. I told him the time was rather short and that I could not give much of a paper, but perhaps I could give a little talk on the subject; but to do anything like justice to it, would require a large amount of space and time.

What I will try and do in this brief talk is to give a few hints on the subject from the best firms and experimenters, together with a few illustrations of work done by myself.

Oftentimes engineers and mechanics are away from good steel workers, and have a cold chisel, drill or other tool they want tempered. Of course, there is the country smith somewhere in the county who will undertake to do it. If he happens to make a good job once, he will tell you that he can temper anything; but the chances are where he succeeds once he will fail a dozen times, and then he has no end of abuse for American steel. "It is poor American steel. If I just had a good piece of English steel, I could make a chisel that would skip anything." But if you should get the best English steel, he would not hit it every time, and, of course, when he didn't, it would be a "poor piece." I find the word *English* has a wonderful effect on steel, or rather has had in the past. A man in Cleveland, who sells all kinds of steel, told me this summer that he had one firm that he could not get to use a piece of American steel. He got the firm to let him take a skilled steel worker in and make some tools, show them how to work the steel and what it would do, then the men would not use it. The proprietor was satisfied that the American steel was good and would like to use it, but no persuading would make the men do so. The steel merchant said he would put an English name on the steel. This was done and the steel did most excellent work, "Quite English, you know." This steel was, as I am glad to say, from the Detroit Steel Works of this city. The best tools I ever used were made of Detroit and Crescent Steels.

The Crescent Steel people, of Pittsburg, are taking untold pains with their steel, and for myself, I would rather have it than any English steel I have ever used.

WHY STEEL HARDENS.

One word about why steel hardens. I have been asked this question often, but have had to say I could not tell, nor have I been able to find out. If we did know, it would probably be an explanation to some of the curious freaks it takes. I will

give, however, what is generally thought to be the best theory I believe. Still this is merely a theory. Now, the theory is this:—

Steel is said to be composed of molecules of iron held in a fixed correlative position by virtue of the molecular forces, and between contingent molecules there exist certain known physical pores. It is conceived that carbon is absorbed and retained within these pores by force of attraction exerted by molecules of iron and atoms of carbon. The molecular force of attraction is opposed by another force which is due to heat, and the balance of these forces is called the resultant force. These forces exerted by continuous molecules being balanced in each physical pore, each force represents a distinct resultant force. Therefore the resultant forces may vary in different pores. If so, the absorption and retention of carbon will not be uniform. Any variation of temperature in any part of the structure will cause a corresponding change in the resultant forces in such pores as are subjected to such changes, and as this force attracts more or less carbon in proportion to its intensity, it follows then that the change of temperature in any part of the structure causes a redistribution of carbon. Hence, it may be concluded that, though the molecules of iron are fixed in a correlative position, the carbon is transitive, subject to be drawn from pore to pore as the resultant forces exerted at each point change.

Now the heating of the steel has the effect of dilating the metal and giving to the molecules a mobility necessary to enable them to unite; the sudden cooling bringing them rapidly together causes combination. Caron regards the hardening of steel as the result of this combination. Others consider that the molecules are in a state of agitation and that their edges (if we can speak of them thus) are moving in all sorts of directions and that the sudden cooling fixes them in this position.

Now, these are theories advanced by some very prominent men and I have given them to you about as they are found in Janes on The Steel Manufacture.

PROPER WAYS OF HEATING STEEL.

The open forge fires, such as are used in blacksmith shops, are the most convenient ways of heating simple pieces of steel; but, if the piece is long or of much value, this is not a good way of heating. If you have no other means, then bank your fire with fresh coal, place a piece of iron, say two or three inches in diameter, inside the fire, then get it to burning enough to coke the coal a little. As

soon as this is done, pull the iron out and you will have a hollow space for heating the steel, and if you work the fire slowly, the steel will heat evenly. Another good way is to bank a piece of steam pipe in the fire and put the steel in it. This I think is best, as it protects the steel from the action of the fire.

A good way of heating very valuable pieces, where we are quite particular about an even heat, is to take and melt lead in an iron dish over the fire. The lead should be covered with charcoal to prevent the surface from oxidizing, then the lead can be heated to the red heat and the steel placed in it. This gives a very even heat.

Another way of heating is in a gas fire. Where it is possible, this is perhaps the best way, if we have cheap gas. I will give one very crude fire that may be of service to engineers out in the woods and away from forges. Take a little good dry wood and start a fire; when the coals begin to form, place your drill or other tool in them. The drill will heat red hot; then with one hammer as an anvil draw out the drill with another hammer, and temper as I will describe later on.

We have shown how to heat steel, but we also have to employ some element to do the chilling or hardening. The quicker we chill a piece of steel the harder it is. The hardening may be done either with solids, liquids or gases. Most of the hardening is done, however, with some form of liquid. But I am inclined to think that gases can be used more than they have been.

The solids used are sealing-wax, tallow, lead unmelted, and other substances. The liquids used are very many; the most common I will give: water, salt and water and mercury. So far as I know air is about the only gas used, although Jarolimich, superintendent of works on the Danube, has shown that the hardening of steel has been done in steam. He also states that hardening of steel has been very poorly understood, and that it does not harden in the manner generally supposed. His experiments show that steel may be hardened in hot water, boiling oil, melted led and melted zinc, when it is cooled to 752° F.

These facts are rather surprising when hardened steel will soften on being heated to about 400° F. However, if the steel is heated somewhat above that of the melted zinc, say 150°, and plunged into the zinc, it will harden, but if left in the zinc it again softens. We can conclude that the hardening of steel does not depend altogether on being plunged into a very cold

liquid, but depends on the rapidity with which its heat is taken from a high degree to a lower one.

Now the question might be asked, Why not use warm liquids and heat to correspond? Steel hardened in very hot liquids is not very hard and cannot be from the fact that the hardness does not depend merely on the conductivity of heat by the liquid, but also on its power to absorb latent heat, and having a low boiling point. Now I think we come to a very important point in the hardening of steel. If we wish it very hard, use a liquid which will carry a large amount of latent heat and conduct heat well also. Then we can keep our steel at a much lower temperature, thus keeping the maximum stiffness with the minimum expansion.

The reason steel cracks on being hardened is because it is expanded by heat and when plunged into water the outside cools and shrinks, while the inside is still expanded, which causes cracks; but if we keep the expansion low, the steel may be elastic enough to keep from cracking.

I have found where it is possible it is well to have a hole in large pieces so as to cool the center first.

One word about water. I have had men say to me that they could not use the steel on hand, that it was bad, etc. One case I remember of in particular, where the workman could not temper the steel without heating it very high, and then it would crack. I tried it myself and had bad luck. I tried again, with no better results, and made up my mind that the steel was not good.

The next day, however, I tried another piece tempered in condensed steam and it worked all right. The trouble was the hard water. Sometimes if you do not remove the scale from steel, it will not harden well.

When a moderate degree of hardness is required and the piece is very valuable, it is well to use oil; this leaves the steel a little tougher than water does.

It is always well to harden only a little harder than we need to for the work it is to do, as we can keep the heat low. However, it is not possible to harden steel just to the right degree without we have a large number of pieces to harden of the same kind, size and out of a constant steel; so it becomes necessary to make the steel a little harder than we need and then reduce the hardness by applying heat. This is what is known as the tempering process. If the surface of the steel is polished after it has been hardened and is heated to about 450° F. there will appear on the surface at first a pale yellow, afterwards all of the colors of the spectrum down to dark blue.

The first is very hard and the last is very soft. This forms what is known as the tempering scale, and all degrees of hardness lie between the two extremes.

We have thus far found out how to heat steel, what to use in hardening, how to harden, and how to temper. Yet something should be said about the degree of heat. This is a point which I find men most ignorant in, and is the cause of untold trouble.

Tool steel should never be heated above a white heat and is better if it is not heated above the red heat, as the carbon at the high heats has too much affinity for oxygen and passes off.

I will give you one of the most important ways of ascertaining what heat to use. It was discovered by the Crescent Steel Works of Pittsburg.

"We take a bar of steel of ordinary size, say about an inch by a half, heat six or eight inches at one end to a low red heat, nick the heated part all around the bar, at intervals of half to three-quarters of an inch, until eight or nine notches are cut. This nicking is done at a red heat to determine the fracture of the nicks. Then place the end of the bar in a very hot fire, leaving the balance of the bar so much out of the fire as to heat it chiefly by conduction. Heat the end of the bar in the fire to white hot, or until it scintillates, and allow it to remain until the nick farthest from the end in the fire is not quite red, and the next barely red. Now, if the pieces be numbered from one to eight, beginning at the outer end,—

"No. 1 will be white or scintillating.
"No. 2 will be white.
"No. 3 will be high yellow.
"No. 4 will be yellow or orange.
"No. 5 will be high red.
"No. 6 will be red.
"No. 7 will be low red.
"No. 8 will be black.

"As soon as heated as above described, let the bar be quenched in cold water, and kept in the water until quite cold. After cooling, the bar should be carefully wiped dry, especially in the notches. An examination of the different parts by the file will show the following, if high steel has been used:—

"No. 1 will scratch glass.
"Nos. 2, 3 and 4 will be excessively hard.
"Nos. 5 and 6 will be well hardened.
"No. 7 about hard enough for tap teeth.
"No. 8 not hardened.

"In breaking off the pieces, which should be done over the corner of an anvil, and the pieces caught in a clean keg or box to keep the fractures clean and bright, it will be found that

"No. 1 will be as brittle as glass.

"No. 2 will be nearly as brittle.

"Nos. 3, 4 and 5 will break off easily, each a little stronger than the other.

"No. 6 and 7 will be very strong, and much stronger than No. 8 or the bar unhardened.

"Place the pieces in the order of their numbers, fitting the fractures. Then 'up end' each, beginning with No. 1 and following in the order in which they lie, and the result will be the series of fractures, as shown in Plate XXII, each differing from the other.

"No. 1 will be coarse with a yellowish cast, and very lustrous.

"No. 2 will be coarse and not quite so yellow as No. 1.

"No. 3 will be finer than Nos. 1 or 2, and coarser than No. 8, and will have a fiery lustre.

"No. 4 will resemble No. 3 in color and lustre, with somewhat finer grain, and will be coarser than No. 8.

"No. 5 will be of about the same size grain as No. 8, but will have fiery lustre.

"No. 6 will be much finer than No. 8, will have no fiery lustre, will be hard through and very strong. This is what is called refined by hardening.

"No. 7 will be refined and hard on the corners and edges, and rather coarser and not quite so hard in the middle. This is about the right heat for hardening taps, milling tools, etc., the teeth of which will be amply hard, while No. 8 illustrates the original grain of the bar.

"In almost every case the bar will crack along the middle to the refined piece (No. 6). In the illustration the crack shows very plainly in No. 4. This crack has never been known to extend into the refined piece, although the experiment has been many times repeated."

From this experiment the following conclusions are drawn concerning the effect of heat upon steel:—

"1. (a) A difference in temperature sufficiently great to be seen by the color will cause a corresponding difference in the grain. (b) This variation in grain will produce internal strains and cracks.

"2. A temperature so high as to open the grain, so that the hardened piece will be coarser than the original bar, will

cause the hardened piece to be brittle, liable to crack and to crumble on the edges in use.

"3. A temperature high enough to cause a piece to harden through, but not high enough to open the grain, will cause the piece to refine, to become stronger than the untempered bar, and to carry a tough, keen cutting edge.

"4. A temperature which will harden and refine the corners and edges of a bar, but which will not harden the bar through, is the proper heat at which to harden taps, rose bitts and complicated cutters of any shape, as it will harden the teeth sufficiently without risk of cracking and leave the body of the tool soft and tough, so that it can yield a little to pressure and prevent the teeth tearing out."

To test a piece of steel, take and draw it out into a cold chisel of about 30° or even 20°, then sharpen to 60°; if it cracks in this process, it is of no use; but if not, heat to the proper heat as indicated by the Crescent people's method, and plunge into water at 60° or 70° F. and draw the temper to a blue. If this chisel stands up well on wrought iron, it is very fair steel, but if not, it is probably poor. It is well, however, to try a second or third test. If it breaks, it may need to be a little softer, or if it turn, it may be made a little harder; but, if it will not temper hard enough to keep from turning without breaking, the steel is of no use. C. G. TAYLOR.

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MEANS EMPLOYED IN RUNNING A STRAIGHT LINE.

THE most important instrument used in running a straight line, is a well-adjusted transit. There are so many text-books which give full directions for adjusting instruments, that that matter will not be discussed here. Next, and equally essential, is a firm, solid foundation upon which the transit is to stand. Swamps and marshes are not the only places where the shifting weight of the transit-man will throw the telescope out of line sufficiently to produce one of those eye sores known as "swings." Made ground in cities and villages, which has been formed by making the original hole a dumping ground for brush and rubbish, and then covered with a thin layer of earth for grass to grow, or holes filled up with slabs, listings, saw-dust and shavings, then sodded over, are often more unstable than swamps. In such places it is difficult to drive stakes for a good foundation. Even if they can be driven down, some part of the incongruous mass will be quite sure to throw most of the weight of a man against one of them. As soon as he changes his position the instrument will be disturbed. A hub should not be placed near a large tree in river or creek bottoms, nor in swamps, as a very gentle breeze will sway the tree enough to shake the ground for a distance of twenty or thirty feet from it.

In a swamp where the muck is more than ten inches deep, it is well to drive three stakes. They should be driven in the direction which the tripod legs will stand when set up, for obvious reasons. Sometimes the muck is so deep, that when large, long stakes are used, one position must be maintained if the transit is kept in line. In such a case one man should be called back and placed behind the transit. When both have found a position where they can move their bodies above the hips, sideways, without disturbing the instrument, the transit-man will turn the vertical hair on the back sight, reverse the telescope and allow the man to place the color pole. The operation should be repeated several times—the men changing sides—to insure accuracy. In the winter time, shaded places should be selected to set up on, especially if the temperature is above the freezing point. Then, the transit must be watched constantly, for it will surely settle off of the tack, and may have to be re-set four or five times if it stands over a hub half an hour.

There are many methods used by different persons for projecting a point in a right line. One, which is time honored, is to have a back flagman hold a color pole over the last

point. This is a good way, provided each one has done his part of the work correctly, but it leaves no backsights standing, so that you can check on them when set up in favorable locations. The back flagman must be skillful and able to hold the color pole perpendicularly over the point. He must not be sleepy, and always ready for business when needed. A man of such qualifications cannot always be found, so backsights, made from small, straight saplings, have been made to take his place. In an open country, these backsights are usually beveled at the top, leaving a ridge about an eighth of an inch wide. The backsight is plumbed up back of the transit, before pulling up, with the ridge placed just back of the eye-piece of the telescope. Through the woods, two pieces of paper, or two pieces of bark, with the light side forward, are fastened crosswise to the backsight with a tack. The paper, or bark, reflects considerable light, and it can be more easily found. The tack, or beveled top, when placed at the eye-piece of the telescope, is the point used in sighting back.

It is well to instruct the head chainman to drill a hole in the ground six inches back of the hubs, to set the backsights in. He should have the color pole placed with the instrument, before drilling the hole, then when the backsight is placed in it, and the tack, or beveled top, placed to the eye-piece of the telescope, you will know that it is plumb.

There is still a better way. Have a man set numerous sights ahead of the instrument. Pieces of card-board or paper can be tacked to fences, small sticks driven into tops of stumps, or ordinary backsights set up. When sights like these are placed as often as every two hundred feet, there will be little chance of error.

A backsight set in the ground, may be pried out of line by a root, or other substance, so slowly that it will not be noticed unless there are two or more fixed points by which the movement can be detected. With so many different kinds of sights, set by the aid of the instrument, any disarrangement of them will be quickly noticed, and can be corrected before any damage is done.

In setting tacks in hubs for transit points, if the color pole is bent or inclined slightly, or if the shoe is not set so that its point is exactly in line with a perpendicular line running through the center of the color pole, the tack will be out of line. When only a portion of the color pole can be seen, it may be held awkwardly and the tack placed considerably to one side.

With several sights to look back at, errors in transit points will be discovered, *because you have two or more points in a straight line to check on.* If only one backsight is used, or if a color pole in the hands of a back flagman is held over the last tack, the point taken from either is assumed to be correct. The transit point over which the instrument is set is also assumed to be correct. Now if the assumptions are true, there will be a straight line.

We have seen how a backsight set in the ground may be pried to one side. The back flagman and his color pole are liable to the same errors that may occur to the head chainman in setting transit points, so it is a risk to assume anything.

The conclusion that I have reached in this matter is, that it is best to use the back flagman in setting as many sights as he can put in, and put the cost of his color pole toward making a perfect one for the head chainman.

The head chainman, or the man who carries the color pole, selects places to set up on, and gets the transit points, is a very important factor in running a line. Nearly as much depends upon him for accuracy and speed as upon the transitman. He should be thoroughly drilled in everything in his line of duty. He should be taught to hold a color pole perpendicularly, by clasping it lightly between the thumb and forefinger of both hands, and the hands held above the head. The point should be lifted a little above the ground or hub. He must keep it squarely in front of him, and move his body the same distance that he does the color pole, when getting a point. As soon as the "All-right" signal is given, let go of the pole. It will fall vertically and make the point plain. If the pole is held to one side it is apt to have some uneven pressure given which will make it incline more or less.

It is quite certain that a man cannot stand awkwardly and hold a color pole accurately. He must be able to judge of the firmness and stability of the ground to set up on. He must select places where the longest sights can be had, and in running through timbered country, he should select transit points where the ground begins to ascend or descend. If any deep ravines or gullies are to be crossed, he must select points to get across them with the least possible chopping, and without having to set up on the steep side hills. He must know something of the reflection of light, so that when he goes to select a point, he will not get on the shaded side of a big tree, but get where the most light comes in through the leaves. A small limb cut out of the way will often let in a wonderful amount of light, or a white handkerchief spread over the

chest, or a light colored straw hat held in the right position, sometimes reflects enough light to show up clearly, objects which before were blurred and indistinct. In fact, he must be a man of gumption and equal to any emergency.

But he cannot do good work unless he is provided with a good color pole. It should be made from a good piece of straight-grained timber. I have found white, or Norway pine to be the best. It is fitted at the bottom with a shoe made from gas pipe, with a steel point welded on, and finished by turning down in a machine. The shoe ought to be of sufficient weight to bring the center of gravity within two feet of the bottom, so that it will have a greater tendency to hang vertically when held up.

The sizes of color poles vary according to the place where they are used. If one is dressed down with planes to a six or eight-sided stick, tapering slightly toward the top, it will keep straight much longer than a stick turned in a lathe. I do not know of any way, however, that one can be made which will never warp or bend. The shoe should be made of sufficient size to receive the stick, without dressing it down to go into the socket. Several trials will have to be made before they can be fitted to each other correctly. When finished it should be thoroughly tested, to see if the point of the shoe has been set in line with the center of the pole. To make this test, suspend a plumb bob from a point in a ceiling, and mark on the floor the point carried down. Fasten a string in the center of the top of the color pole and suspend it from the same point. If the point of the shoe covers the mark on the floor it is all right. Prying with a color pole should be prohibited.

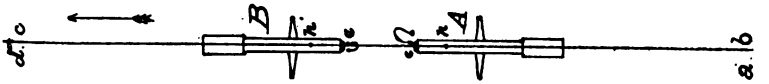
These remarks about the head chainman and color poles may seem extended and to deal with tiresome details, but it is exasperating to a trained man to take a good transit into the field, use care in keeping it in adjustment, and then have all of his pains go for naught, on account of a "chump" or a crooked stick.

A friend of mine exhausted his patience and his supply of men, trying to find one who could do the simple act of holding a color pole plumb, and as a last resort, had one made with a shoe so heavy that a man with ordinary strength could not hold it in any other position.

Sights should be equal in length if possible. None of them less than 200 feet, and of as great length as signals can be seen and understood.

Hard winds and refraction make work very uncertain. Clear, cool days are the most favorable for fine running.

A man may select the best transit, a well-trained head chainman, a perfect color pole, and use every precaution in running a long tangent, and when he has finished, may be greatly vexed and mortified to find instead of a straight line, he has run an arc to a circle, which has a long radius. If he starts out to review his work by repeating the work at each hub, he may discover no inaccuracies there, but can only see that it is a curve, as he looks at a large part of it at a time. I can only explain this in the following way: Some instruments have an eye-piece which is so large that when the eye is moved back and forth at right angles to the line, the cross hair appears to travel across a fixed point. Most men stand on the same side of the line and use the same eye, when looking either backward or forward. Now, suppose a man stands at the right side of the line and uses his right eye, and



has a transit of this kind. In the drawing let A represent the telescope pointed backward toward the backsight, and B the telescope reversed over the same point and *b c* the line of collimation, *h* and *h'* the cross hair. Standing on the right side of the line, the eye will naturally be on the right side of the line of collimation. When looking at the backsight *a*, the telescope will be clamped when the cross hair covers the point, but instead of the telescope pointing toward *a* it really points to *b* in the line of collimation. So when the telescope is reversed and the man endeavors to set the point *c*, he will set the point *d* which is in line with his eye *e* and the cross hair *h'*. The distances from *a* to *b* and from *c* to *d* are slight and nearly equal, and the points *a* and *d* are points in a curve, tangent to the line of collimation. If the work is reviewed from hub to hub this error will not be noticed. Only when a number of them are seen on one side of the instrument will the curvature be apparent. There is also a personal error which enters into line running. It is also noticable when two persons run levels over the same line. The error is quite uniform and may of itself produce a slight curvature.

It would seem then that if a man ran a straight line of great length without error, he will do well to divide the credit about equally between his skill and good luck.

GEORGE L. WELLS.

Mr. Sears.—"I would like to ask Mr. Wells whether he relies upon his transit in getting a straight line without getting a double center. The only way to get a straight line is to reverse the transit and take a second point and get the center."

Mr. Wells.—"I should do this if the transit were out of adjustment, but I keep my transit in adjustment so that it would make no difference."

Mr. Hodgman.—"I would ask Mr. Wells, in the case he mentions, where there is an apparent motion or traveling of the cross wires, whether he noticed if the lenses in the telescope were properly focussed."

Mr. Wells.—"It was fixed on the object."

Mr. Hodgman.—"If the eye-piece was not correctly focussed on the cross wires, it would cause the apparent traveling of the wires."

Prof. Davis.—"I think you will get rid of that trouble if you test the eye-piece."

Mr. Sears.—"If he always takes double centers with care and skill he will be all right."

Mr. Hodgman.—"That is a sure way. I seldom do it, because I keep my instrument in good adjustment. I use backsights with a fine point, and leave them all standing where set. It often happens that from some point I can get a range back over quite a number of these points. Then if the instrument is the least bit out, I detect it at once and apply the correction. It is very seldom that I run a line for any considerable distance without an opportunity of this kind for checking up the adjustment of the instrument, as well as testing the accuracy of the line."

Prof. Davis here exhibited some light transits made by Buff & Berger, of Boston. "One thing the gentlemen will want to know is the price. They cost just about as much as a larger instrument. The work is finer on them. They will do just as good work as the larger instruments. An instrument of that size has been used in extensive triangulations, with accurate and satisfactory results."

Question.—"How close do they attempt to read them?"

Prof. Davis.—"Mine is graduated to read to half minutes. That instrument you have weighs 5½ pounds. The tripod weighs the same. For one, I have got through carrying about a twenty-pound transit on my back. I could tell you any number of stories in regard to the work of this little instrument. It is large enough for any ordinary use."

Mr. Wells.—"How about leveling with the transit?"

Prof. Davis.—"I must express my want of confidence in the level made on the transit instrument. For ordinary surveying, for sidewalks, etc., the level on the transit may be used."

Mr. Sears.—"Mr. Davis must excuse me if I am prejudiced against these small instruments. They are badly agitated by the wind. They have been lightening the tripod, and now they are lightening the instrument. I would like to see a man manipulating this in a cold day. It is well enough for a young man to get down to a fine point, but I prefer a large instrument."

Mr. Hodgman.—"Has Mr. Sears had any personal experience in the use of these light instruments?"

Mr. Sears.—"I have not. I would not use one of them."

Mr. Hodgman.—"Well, I have. From 1868 until 1881, when I went into the Denver & Rio Grande Western Railroad Survey, I used the heavy transit exclusively. When I went there I sold my instruments to the company. It was a hard place on instruments and I had a good many different ones in my party of all sorts of makes. The transit which did the best service and was every way the most satisfactory of any I had, was the lightest one of all, and was made by Young & Sons, of Philadelphia. It got to be pretty well known along the line, and not a little strategy was used by different transit men to get that instrument. In 1882 I purchased a Gurley light mountain transit, which I sold last year, and I now have another of the same make. I find by eight years' use of these instruments, that I can do as accurate work with them as I could with the large instruments. So far from being unstable, they stand more firmly in the wind than the large ones. They have just as broad a base of support on the ground, with very much less surface for the wind to get hold of. After fourteen years' use of the heavy transits and eight years of the light one, I have got so lazy that I would not take a heavy transit as a gift, and be obliged to carry it, if I could buy a light one at present prices. I have more confidence in the level on the transit than Prof. Davis

has. I used to feel just as he does about it. But I have always had a good deal of mixed surveying to do where I had to both run lines and take levels. This led me to make a number of extended and careful tests of the level on my transit, and I found, as the result of those tests, that the levels on the transits that I tested were plenty good enough for any work I have to do. Hence, I do all my leveling now with my transit and save lugging an extra instrument about the country when I have both kinds of work to do.

The following figures are taken from the notes of one of these tests. A line was run from Barron Lake to Niles with a Gurley Light Mountain Transit, leveling by stations with the transit as the line was run. It was then leveled a second time by stations with a 20-inch Gurley Wye Level. The following table gives comparative heights as taken by the two instruments:—

Station.	Height by Transit.	Height by Level.	Station.	Height by Transit	Height by Level.
0	100.00	100.00	175	75.17	74.91
25	115.03	115.39	200	74.10	74.17
50	109.36	109.25	225	72.73	72.77
75	106.84	106.90	250	65.18	65.31
100	94.86	94.93	275	34.66	34.92
125	86.95	87.39	279	32.04	32.32
150	77.65	77.98			

Mr. Davis.—"Mr. Sears has referred to his prejudices. Just as long as Mr. Sears is above ground we will respect those prejudices, and if he is going to lug a big instrument, we are going to let him, and the more years he lives to do it the better we will like it."

Mr. Wells.—"I used a small transit like Mr. Hodgman's and a large one side by side on the same work, and in closing there was a difference of about 2′ in favor of the larger instrument."

Prof. Carpenter.—"Other things than the size of the instruments may have caused the difference."

Mr. Hodgman.—"It is not so easy to read the smaller graduations, but I use a magnifying glass and have no trouble."

Prof. Davis.—"If the verniers are made correctly on the small instrument, there will be no difficulty in reading them."

YPSILANTI WATER WORKS.—ABSTRACT.

I HAVE been engaged during the past season in planning and constructing a system of water works for the city of Ypsilanti, and while there is nothing originally new or novel involved in the construction of these works, yet I think there is very much that is well worth the attention of all persons professionally or otherwise interested in such public improvements.

The plan of works adopted at Ypsilanti is based on the pumping and elevated reservoir service combined, both ordinary service and fire service being furnished direct from the street mains. There is a very broad distinction between the system of works I am here describing, and what is commonly called the pumping to stand-pipe system. Of all the water-works systems, where pumping is required, I claim the Ypsilanti system is the best in all respects.

It is superior to the pumping and open-earth-reservoir system, chiefly from the fact that the water in the perfectly enclosed elevated reservoir cannot deteriorate from exposure, as in the open reservoir. It is superior to the simple so-called direct-pressure service, both in economy and efficiency of service. In the direct service, an instant stoppage of our pumping machinery, and the entire service is dead. In no case can the service from such works exceed the simple capacity of the pumps. Nothing can be stored up for use in time of necessity, while to be prepared to meet extraordinary demands, we must keep expensive reserve machinery in constant readiness for use.

It is impossible to pump water economically in the direct service, because we never know what we have to do. At one hour of the day we may be called upon to run our pumps at their full healthy capacity, at another hour of the same day, perhaps only one-fifth of this service will be required, yet we must be ready at all times to meet all calls as they come. With our elevated reservoir we are perfectly prepared at all times for all emergencies. We can run our pumps at all times at the same speed, and under the same pressure, working to their full economic capacity, regardless of the current consumption; whatever excess of water there may be pumped, above the ordinary current consumption, will go to the reservoir, there to be stored to carry the night service when the pumps are idle, or to meet any demands that may temporarily exceed the pumping capacity.

To illustrate, we are building works for a small city where a half million gallons of water per day will be the maximum consumption for ordinary service. If we are to have a fire service, as well as ordinary service *direct* from the mains, we must be prepared to meet short calls for fire service, *four times* greater than this maximum ordinary service. If we are working under the simple, so-called, direct pumping plan, having nothing but our pumps to rely upon, then these pumps must be of *five times* greater capacity than needed for our ordinary work, and this excess must always be kept in readiness for *instant use.* The amount of water required for fire service for a whole year, averages less than *one day's* ordinary consumption, yet, to do this *one day's* work on the *direct* plan, we must keep our *four-fold* excess of pumping capacity in readiness for 365 days in the year.

In nearly all our public water-works systems the amount of water running to waste greatly exceeds the amount used for strictly necessary purposes. I think it is safe to say that seventy-five per cent of all the water used, escapes from faucets partially opened and constantly running. These openings are all gauged to give the required amount of water under the *ordinary* pressure; a fire breaks out, and at once the pressure must be doubled, your waste is doubled, and your fire service handicapped. Your pumping machinery is usually not adequate to meet all these demands effectively. Your mains are not large enough to carry this amount of water without a frictional loss that will very seriously impair the efficiency of such service as your pumps may still be able to render. In many cases your water supply will not be adequate to meet all these wants, and wastes.

The stand-pipe cuts so small a figure in water-works construction, considered purely on its merits, that it would not be worthy of any extended notice, but for the fact that the great majority of the people hold such vague ideas concerning it.

The original intent of the stand-pipe, was to provide a relief for the pumping machinery and mains against the shock of suddenly changing pressures. A stand-pipe of proper height, and in size equal to the force main, would serve this purpose as well as one of larger size. Of late years, stand-pipes of much larger size have become quite popular with many engineers. The only added merit these larger stand-pipes possess consists in their added storage capacity, and this is too small to cut any important figure. A stand-pipe fifteen feet in diameter, and one hundred and fifty feet high

will hold a little less than two hundred thousand gallons of water, counting from the ground up, and will cost ten thousand dollars, or five cents per gallon for every gallon of water it contains; if we enclose it, as ought to be done, then it will cost as much more. But only *one-fourth* of this water will do *effective work*, so that this raises the cost of our structure virtually to twenty cents per effective gallon, if naked, or forty cents per gallon if enclosed. Such a structure cannot do fire service longer than thirty minutes without reinforcement from the pumping station, nor can it do good ordinary service long enough to enable us to reduce the working force at the pumping station.

A properly constructed water works, on the pumping and elevated reservoir plan, should consist of a pumping plant of at least double the capacity required by the maximum consumption of the ordinary service, so that the full twenty-four hours' supply can be pumped by working half time, with one set of men, and a reservoir of sufficient storage capacity to carry the ordinary service during the night, and to meet the demands for fire protective service at all times. The reservoir must be placed at sufficient elevation to afford sufficient fire service by the simple gravity pressure of its waters.

In order to secure the best results, the pumping station and reservoir should be on opposite sides of the city, the street main distribution lying between. This arrangement will reduce the frictional loss in the mains to a minimum, and secure the highest degree of efficiency in the service. The pumps and reservoir will be connected directly through the street main distribution, and when the pumps are running, all the ordinary service will be supplied direct, the pumps always running up to their full economic capacity, without any regard to what may be transpiring throughout the distribution, the aim being to pump all the water in ten or twelve hours, that will be required during the twenty-four hours.

Of course the excess of water pumped, beyond the ordinary current requirements, will pass into the reservoir, there to be stored for the night service, and to meet any extraordinary demands that may arise. Should a fire break out during pumping hours, calling for water in excess of what the pumps are delivering, no attention need be given it at the pumping station, as the moment the pumps fall short of supplying the demand, the reservoir will come to the rescue with its reserve power, and both reservoir and pumps will work effectively and harmoniously together. It is now that the importance of a proper placement of our pumps and reservoir will most plainly

appear. If our pumping station and reservoir had been placed in juxtaposition, compelling both to work through the same main, from the same direction, instead of working in harmony and full effectiveness, there would be constant conflict and but half service could be rendered. It would not be possible to establish an effective, frictional equilibrium between the contending forces.

In planning and constructing the Ypsilanti Water Works, it has been my aim to harmonize all these elements, and to develop a service of the highest degree of economy and efficiency, and its natural advantages have been highly favorable to this end. Nearly three years ago I visited Ypsilanti, and made a preliminary investigation relative to the development of a public water supply. I found everything favorable to success. In April last the people voted to bond the city for seventy-five thousand dollars, the money to be used in developing a system of water works; I was employed by the Board of Water Commissioners to plan and superintend the construction of their proposed water works. In the commencement, it was deemed best to only put on about ten miles of street mains, with a small steam pumping plant and an elevated reservoir. Later it was found that an excellent water power, fully equipped for service, was available, and it was deemed best to purchase this water power, and abandon the steam pumping plant part of the plan. The adoption of the water power increased the first cost of the proposed works about twenty thousand dollars. As the work progressed, a demand sprung up calling for a large extension of the street mains, the result being that an additional fifty thousand dollars in bonds were voted, and additional mains were put down, until the total street main distribution reaches nearly eighteen miles. This gives Ypsilanti two and one-half miles of street mains for each one thousand of her population, which is more than double the average of the cities of the United States having water works, and renders her more perfectly equipped in her public water-supply service than any other city in the State.

This liberal provision in the outset has proven wise, and fully justified by the results. The people are more generally satisfied, as the entire city now enjoys the *full benefit* of the improvement, whereas with only ten miles of street mains, as at first intended, only about one-half the city would have been directly benefited. These works start out, from the day of their opening, as a *self-sustaining* public improvement. I think this is the first case of the kind on record.

The plan adopted in constructing the works will account for this. Utilizing our water power, we brought into requisition a temporary pump, and, taking water from the river, filled the mains as fast as laid, the object being mainly to provide water for puddling the back-filling of the trenches, and to furnish fire protective service from the hydrants as fast as set. In sixteen days from the opening of the first trench, we threw fire streams ninety feet high, direct from the mains in the heart of the city, three-fourths of a mile from the pumping station; and in ninety days all the street mains were in place, and the city fully provided with effective domestic and fire-protective service. Soon after commencing pipe laying, applications began to come in for permits to tap the mains for water for lawn sprinkling. This demand exceeded the capacity of the pumpers to meet, and kept in advance until the close of the season. Between four and five hundred connections were made before the close of the season, and before the works were completed and formally opened. Had the Board been able to keep pace with the demand of the applicants, there would doubtless have been eight hundred paying connections with the mains before the works were completed and formally opened. We did not wait for the completion of this branch of the work before starting in on other parts of the work, but commenced and prosecuted all simultaneously.

The water power and buildings of the Ypsilanti Paper Company, located in the southern part of the city, were purchased by the city, and the pumping plant located there. The supply well was located about one thousand feet from the pumping station, on the opposite side of the Huron River, which, running from north to south, bisects the city. This well consists of a circular caisson thirty feet in diameter, constructed of iron and masonry, the sides being impervious, and sunk to the depth of thirty feet, terminating in a stratum of water-bearing gravel. Fifteen feet of hard pan, of such tenacity as to require blasting, overlaid this water-bearing stratum. When the water was reached it overflowed the surface of the ground. This water supply is ample in quantity for the utmost requirements of the city, having been tested to more than three millions of gallons per day, and the quality of the water cannot be surpassed.

The pumps are conneted with this well by a sixteen-inch suction main, running under the river, in the same trench, and parallel with the twelve-inch force main. One and one-half miles from the pumping station, diagonally across the city, is located the elevated reservoir. The ground upon

which this structure is built is one hundred and three feet above city datum.

The reservoir is constructed as follows: First, a substructure of masonry, circular in form, forty-two feet in diameter, and eighty-five feet high is constructed. The walls are of Joliet stone, laid in cement mortar. The outer wall is in true circular form, three feet four inches thick at grade line, and two feet thick at top, or base line of reservoir. There are three parallel walls, at equal intervals inside, running entirely across and intersecting the outer or circular wall. These walls are each of the same thickness and height as the outer or circular wall. The excavation in which the foundation for these walls is laid, is circular in form, fifty feet in diameter, and covered solidly to the depth of six inches with very rich cement mortar. Upon this are laid the footing courses for the walls above. These courses are of dimension stone, laid in terrace form, each course being sixteen inches in thickness, the first course for all the walls being six feet in width, terminating at grade line in a course four feet in width.

Crossing the wall at top, in parallel courses two feet apart, at right angles with the walls, are steel floor beams ten inches in depth, for the reservoir to rest upon, the walls being built up between the beams, flush with their upper surface. These beams project thirty inches outside the masonry all around.

The reservoir consists of a steel tank, circular in form, forty feet in diameter and twenty-seven feet deep, and resting upon the floor beams and walls of the substructure. A sixteen-inch main connects the reservoir with the street main distribution, and an eight-inch overflow pipe leads to the sewer. This reservoir is entirely enclosed with a structure of wood. This building rests upon a circular plate of steel, bolted to the ends of the projecting floor beams, is circular in form, rises perpendicularly as high as the top of the reservoir, and from this line a dome roof is spread over the whole, terminating in a cupola with glazed windows in each of its four sides. There is two feet of clear space between the outside of the reservoir and the inside of the walls of the enclosure, and twenty-two feet of clear space from top of reservoir to base line of cupola. The cupola is two hundred and fifty feet above city datum, and will be provided with a cluster of electric lights.

The capacity of this reservoir is a little in excess of a quarter of a million gallons, which is thirty-five gallons per capita for the entire present population of the city, and *every gallon* of this water is always available for full, effective fire

service. The full reservoir will furnish six effective fire streams, for six consecutive hours, without reinforcement from the pumps. This reservoir will be ample to render full service to the city for at least five years, after which it can be duplicated on a corresponding summit on the opposite side of the river and city, a central twelve-inch force main leading from one summit to the other. This main is already laid. The present force main from the pumps through the distribution, is twelve inches in size, and runs through the main part of the city on the west side of the river. Five years hence the plan contemplates a duplicate twelve-inch main on the east side. The present arrangement will supply all demands up to that time, and the plan, when fully completed, will be better than if a larger *single* force main had been provided in the outset.

With the plan fully carried out, the pumping station and the two reservoirs will occupy the three points of a triangle about equidistant, with the entire street main distribution enclosed. Under this arrangement we will secure a very high degree of effectiveness in the service, the frictional loss of the water passing through the mains being very small. The street main distribution is so arranged as to give a double-discharge fire hydrant at every street intersection. The mains cross the river five times, giving full service to all parts of the city.

The pumps are power pumps of an entirely new pattern, are triplicate in form, and promise to give an exceptionally high economic duty. Running these works by water power will save much expense.

There is water sufficient all the year to operate the pumping plant, and for nine months in the year there is more than needed. The city will utilize this extra power to run its electric street lighting plant, which is now operated by steam power. The electric plant is being placed in the pumping station, and will be run by the same power as the pumps, when there is sufficient water; when not sufficient water, then by a Corliss engine attached to the same line shaft, being so arranged as to permit of instant change from water to steam, or the reverse. It is estimated that this arrangement will save the city five thousand dollars per year in running the two plants, as compared with running both by steam.

The cost of the Ypsilanti Water Works has been a little less than one hundred and forty thousand dollars. Ten thousand dollars of this, however, should be charged to the electric light plant, and five thousand dollars to the private service

development fund. This will leave the actual cost of the water works, one hundred and twenty-five thousand dollars. The elevated reservoir cost seventeen thousand dollars, which is about six and one-half cents per gallon of its waters. The interest on the cost of these works, and the current running expenses, will not exceed eight thousand dollars per year. The revenue from private rates will exceed this at the end of the third year, and the city council has only to credit the water works an exceedingly low rate for fire-protective service, to provide a sinking fund that will take care of all the bonds issued for the *entire work*, long before their maturity; and this without levying one dollar in taxes to redeem these bonds.

In the construction of the Ypsilanti Water Works, no contracts for work were let, everything being done by day labor.

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PHOTOGRAPHIC SURVEYING.

THE theory or principle of this method of surveying is identically the same as used in plane table work, or, indeed, in any system of triangulation. We must have at least one measured base line, and then we proceed to take angles from various points to the objects to be located, not, however, by actually measuring them as in triangulation, nor by drawing lines toward required points as in plane table work, but by taking photographs which shall include the required objects as seen from at least two distinct points of view. These photographs serve every purpose that is required for making maps, giving not only horizontal angles, but also elevations or depressions, and the location of every object shown on photographs taken from two distinct points of view. All precautions regarding the selection of angles that applies in triangulation or plane table work holds equally true here. If radiating line from different points meet at an acute angle, errors are likely to result—greater as this angle is smaller.

Any method of procedure practicable in plane table surveying is equally serviceable in this. I will, however, describe but one method, that being similar to the one usually used in triangulation. First measure a base line, as *A B*, and also take its bearing, if it is desired to know the bearings of the other lines of the survey. Set up the camera at *A* and sight it on *B* and so as to cover some object toward *D*. If no fixed object can be seen at the termination or limit of view, a flag must be set; this then gives us the angle *D A B*. The next view would include the point *C* and *E*, making the angle *D A C*, if the instrument is sufficiently wide angled, if not it may be divided into two or more views. After taking all the sights needed at *A*, the instrument may then be moved to *B*, then with the instrument sighted on *A*, take as large an angle as possible toward the objects *D* and *E*, and continue until all the objects desired come onto the field of view. The pictures which may be obtained from these different views by a skilled observer,

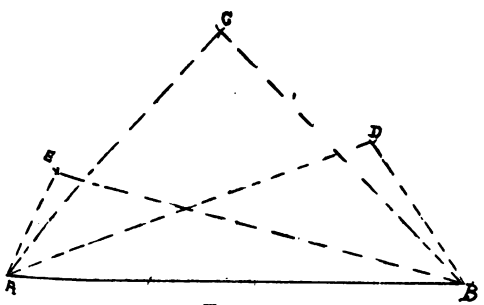

FIG. 1.

with the proper kind of apparatus, will provide accurate information regarding all these various angles. After securing two views on any point its location then becomes known, and the instrument may be moved to that point, after which proceed as in the first instance. Thus the field of operation becomes wider and wider. A practical limitation with this apparatus will soon be found, however, because of the small size of the pictures as compared with the objects, so that distant objects, unless they are very large or bright, can not be found on the picture. This limitation depends entirely on the lens used, the shorter the focal length of the lens, the less the distance objects can be seen.

This method of operation is no doubt comprehended by every one, because it comes directly within the province of the surveyor. The remaining operations involve work heretofore done largely by photographers, and, consequently, are new to our business. I know that surveyors have not been photographers, and at the risk of being tedious, I will describe the essential instruments and processes used in photography, although by so doing I may be going over work very familiar to many of you.

HOW TO PHOTOGRAPH.

The basis of modern photography is the dry plate. This consists of a plate of clear glass, or transparent film of celluloid, covered with an emulsion of gelatine made sensitive to light by the addition principally of bromide of silver. Some of these plates are extremely sensitive, and an exposure even as short as 1-50 of a second, is sufficient to give a clearly defined image. The action of the light changes the nature of the chemicals on the dry plate, somewhat in proportion to its intensity. This change is rendered visible by the application of certain other chemicals called developers. Even after an image is made to appear by the developers, the plate is still sensitive to light, and it must undergo a process called fixing before it can be exposed in white light. Red and orange light have little or no effect on these sensitive plates, and, consequently, they may be examined and handled by light passing through a ruby or orange glass. The necessity of thoroughly protecting these sensitive dry plates from the light when in transit is now seen. Various devices termed dry-plate holders are used for this purpose. They are so made that a shutter can be taken from in front of the dry plate and replaced, when the dry plate is in the camera, without exposing the plate to any light. If a dry plate were to be exposed in the open air, diffused light would act on it and no image would

appear, the whole plate would appear black after developing. There must be some means of concentrating the image desired and shutting off the effect of any other light. It is found that this may be done by a dark box with a small pin hole opposite the dry plate—quite creditable pictures have

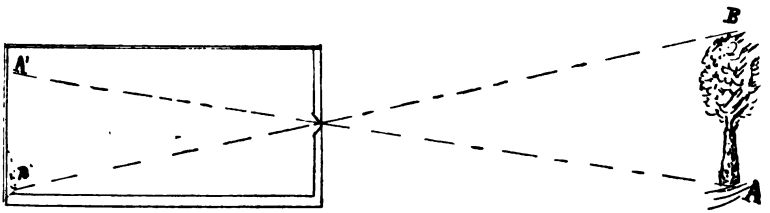

FIG. 2.

been taken in this way. This would be the simplest possible form for a camera. It would need no focussing arrangement; the size of the picture would depend on the length of the box, and the sharpness of the picture on the smallness of the hole. The principle of action is shown in the sketch, by means of which it is seen that the image is inverted as compared with the object. To cut off side rays of light the box should be painted black on the inside. Such a camera, though it might be accurate, would be exceedingly objectionable in practice; since if the hole were small enough to give a sharp image, even the most sensitive dry plate would be exceedingly slow, because of the reduced amount of light. From five to ten minutes exposure would probably be required.

The use of a lens virtually enlarges the hole for the admission of light and still concentrates the rays of light, so that pictures may be taken very rapidly. The use of a lens for photographic purposes is more trying, more difficult to satisfy perfectly, than for telescopic or microscopic purposes. A very short discussion will, I think, make this point clear to you without entering into any abstruse calculations. First, however, we will consider the commercial camera.

THE CAMERA.

The camera for photographic purposes consists simply of a box, the length of which can be changed at will, usually by connecting the back and front with a flexible bellows. In the front is arranged the lens, and in the back is a place fitted to receive the dry plate-holder. When not in use, a ground glass screen takes the exact position of the dry plate when in the act of taking a picture. The image of the object to be taken

is thrown on the ground glass, and by shutting off the side rays of light by throwing a blanket over the head, it can readily be seen. The length of the camera can be changed until each portion of the picture appears sharp and distinct, at which time it is in focus and ready for the picture. When the camera is level, the ground glass must be vertical. If it is necessary to incline the camera upward or downward, the ground glass must be inclined but little from the vertical. This condition requires a swinging back around a horizontal axis, technically called a single swing back. The back is also sometimes swiveled so as to swing on a vertical axis, technically called a double swing back. Both these attachments will simply make a surveyor trouble without ever being of benefit. The angles of his camera should be rigidly at right angles, as the least change of position of the dry plate is fatal to accurate work. One movable feature, and one only, is permissible in the camera for photographic surveying, and that is a sliding front board, by means of which the center of the object glass can be raised or lowered above the center of the camera. The effect is to raise or lower the field of view, through an angle whose tangent is equal to the distance moved from the center position divided by the focal length of the object glass. By means of a table of tangents a scale reading to degrees or even closer can be computed and marked on the front board. Pictures taken under such conditions can be reduced to equivalent horizontal pictures.

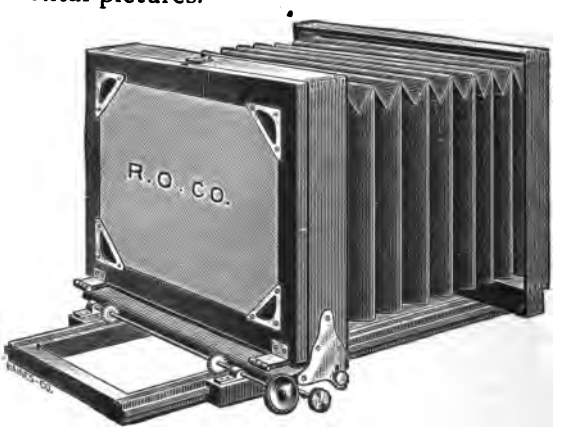

FIG. 3.

After considering the requirements and methods of testing lenses, the adjustments required for the camera will be considered.

THE LENS.

Let us consider for a moment the action of a lens in producing an image. Let *K L* be a double convex lens, *A B* an

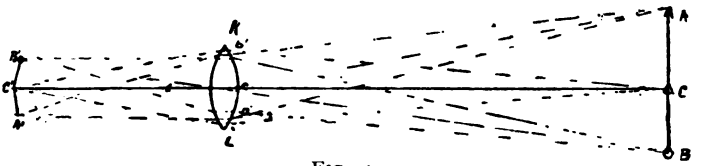

FIG. 4.

object in front of the lens. Rays of light from every point of this object radiate and completely cover the lens. Thus, for instance, from the point *A* in the object, rays of light strike every point of the object glass, for instance *a' e' c'*. These rays of light in passing through the lens are bent toward the perpendicular, and in leaving it they are bent away from it. The effect of this is to converge all the rays of light from the point *A* in the same general direction, or if the lens is perfect, to unite them at same points *A'*. In a similar manner the rays of light from *B* unite at same point *B'*, those from *C* at same point *C'*. We thus have the images of all points of the object formed somewhere back of the lens. These points may or may not be in the same plane, that is the point *C'* may be further from the lens than either the points *B'* or *A'*. In the case of a camera this condition would exist when we get a perfect image in the center of the picture and a confused one along the edges.

A study of the sketches makes another thing evident: as the distance to the object increases, the image approaches the lens, until when the rays of light are parallel the image is at its nearest position to the lens, or is said to be at its principal focus. This is readily seen in the above diagram; the parallel rays of light *A* and *B* meet at *F*, those from *C* meet at *C'*. Since the focus continually changes its position with reference to the lens, as the distance to objects vary, so is the image to be found in various positions. Now then, we find with this change of focus of the center, a change in the relations of the focal positions of the extreme points. That is, we might grind our lens to bring the points *A' B' C'* in the same plane for one position of the object, but we should find that a change in the position of the object would necessitate a new focus and consequently a different adjustment of these relations. The perfect lens for a camera is then a mathematical impossibility, as it involves a changeable form to the lens for each position of the object.

Possibly it needs such a lens as nature has furnished in the organ of sight, which acts under conditions more nearly like these of the camera lens than any other instrument.

That this limitation is less important for the telescope is seen at once, in the fact that we are interested in that case only with the center rays, or those near the center, and we put in stops or diaphragms to prevent any possible injury by interference of the side rays.

Having only the center portion of the image, the error in the shape due to different positions of focus at extreme edge and center, entirely disappears. Achromatic lenses, or those which do not separate the chemical rays of light, as is well known, by forming a lens of two kinds of glass, are even more important in a camera than in a telescope, since these chemical rays act with very different intensity on the sensitive plate.

We will call the first error described above aberration, and will say that it can be much lessened by using only the central portion of the lens to transmit light. This is done in the case of a single lens by placing a diaphragm, with a hole of a definite size in front of the lens. The diameter of this hole is generally some even divisor of the focal distance of the lens, and a large variety of diaphragms is provided with each instrument.

The error of aberration is also reduced by using two lenses in the object glass, placed a short distance apart. As seen from the diagram, the effect of the two lenses is to doubly refract the rays as compared with a single lens. This has the effect to bring the focus nearer the lens, and also reduces the distance between extreme positions of focusing. The effect of this is to reduce the error, or at least make it more nearly uniform, so if corrected at one point it will not be so badly out at others. Thus, with the single lens the focus would be at

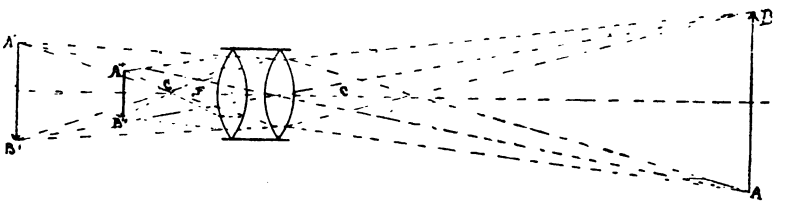

FIG. 5.

$A' B'$, but with the combination it is at $A'' B''$. Despite this improvement of the double lens over the single one, no maker claims to produce a lens without aberration, unless diaphragms are used as previously described. Then he cannot claim its

entire absence, but that it is reduced to so small an amount as to be invisible and immeasurable, at least with certain stops. This condition makes the lens practically correct. The purity of the glass is of as great or greater importance than the figure of the object glass, as every flaw, change of density or color, in time affects the image. In this respect each one of the past few years has marked great improvements, and it is believed that optical glass is now being manufactured that is nearly free from the defects mentioned. In regard to lenses for cameras, the best ones are probably produced in Europe. Dallmeyer of London, and Suter of Berne, are the two most celebrated makers. There are, however, a great many lenses made in this country, many of which are of great excellence. I have myself tried two of American make, the Morrison lens, manufactured by the Scoville Co., and the Bausch & Lamb, manufactured at Rochester, N. Y. In both instances the errors from aberration were less than could be measured. Either of the above makes, if as good as the ones tested by myself, would do satisfactory service in photographic surveying.

TESTING LENSES.

1. Lenses may be tested for aberration by focusing on objects very close and very distant and noting the relative sharpness of the image at the center and edges of the plate. If no diaphragm is used, the best lens made will show some defects, especially if a magnifying glass be used to examine the image. The best test for engineers is to arrange a series of objects at different distances and in different directions from some central station; measure these angles accurately with a transit, then afterward repeat the measurements with the camera. If there is any disagreement whatever, measurable, I should reject the lens.

2. The lenses may be tested for other defects by fastening them in the end of a long tube, with a place for the eye at the other. Make a diaphragm of paper with a small hole so arranged as to be movable and to admit light to different portions of the lens. If the lens is perfect, it will in all cases appear uniformly bright. The last is an important matter if we expect a lens to do satisfactory artistic work.

3. Rotate the lens in a tube; if any shifting of the image appears, the lens is defective, or at least not mounted correctly. This test is much the same as that used to test the line of collimation of a level.

4. Make a photograph of paper ruled in squares like cross section paper, having the photograph as large as can be taken.

If the squares are not of uniform size, or are not perfect in the photograph, the instrument is faulty.

FOCAL DISTANCE OF LENSES.

The focal distance of a lens is the distance at which the image is formed from the center of the lens for distant objects, and must be accurately known before angles can be measured from the photographs. Unless this distance is extraordinarily great, the focal distance of objects forty rods or farther away will not differ sensibly from those at an infinite distance. Hence the determination of focal distance for parallel rays can be used without sensible error for ordinary measurements. The focal distance is always given by the manufacturer of a lens; but so far as my experience goes, their statements are not accurate, and perhaps are intended only to be approximately true. At any rate, it will be necessary to accurately determine the focal distance for each individual lens. It may be done as follows:—

1. Approximately, by taking the lens from the camera and obtaining the focus of the sun on some screen. The distance from the center of the lens to the screen will be an approximate focal distance.

2. Draw a heavy black circle on white paper, say six inches in diameter. Arrange this on the side of a small box so as to remain vertical. Level the camera, and set its center the same hight as the center of the circle. Move the box toward or from the camera, keeping the paper parallel to the ground glass of the instrument, until the image and object are of equal size, in which case the distance from the ground glass to the object is four times the focal distance. This method is applicable only with a camera that will extend about twice as far as the focal distance of the lens.

3. Use the same method, but make the image one-half as large in linear dimensions to the object, in which case the focal distance is equal to 2-9 the distance between image and object. This can be used with nearly every camera.

4. Use the same method, making the image one-third the linear diminsions of the object; in this case the focal distance is equal to 1-5 the distance between object and image.

5. The focal distance may be computed from data furnished by measuring the size of the object, its distance and the corresponding size of the image on the ground glass, by direct proportion, as will be explained hereafter. If n be the

ratio of object to image, the focal distance equals the distance between image and object multiplied by the fraction $\frac{n}{(n+1)2^1}$, or for great distances $\frac{1}{n}$.

MATHEMATICAL CONSIDERATION OF THE FORM OF LENSES.

At this point it seems necessary to investigate some of the relations existing between the form of lenses, size of objects and size of images, in doing which demonstrations will be given for the different cases cited under the methods of finding the focus of a lens.

Because of the difficulty of construction, the forms for surface of lenses are movably spherical. Rays of light in passing through them apparently all intersect at a point termed the optical center of the lens. Considering aberration zero, parallel rays from any point all meet at the same point. This point is in the plane of what is termed the principal focus of the instrument, and its distance from the optical center is the focal distance of the lens.

In the figure

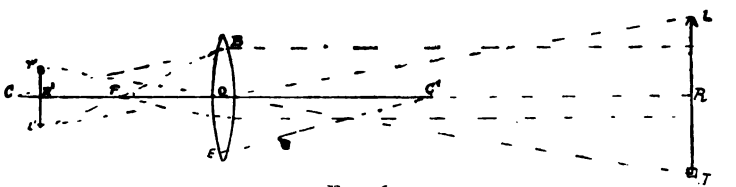

FIG. 6.

Let $C\ B=r$, radius of one surface of lens.
Let $C'\ E=r'$, radius of inner surface of lens.
Let F= principal focus or focus of parallel rays.
Let $F\ O$=its distance to $O=P$.
Let O=optical center of lens.
Let $L\ T$ be any object and $L'\ T'$ its corresponding image.
Let $R'\ O=p'$, its focal distance.
Set $R\ O=d$, distance of object to center of lens.
Let $M=\frac{\text{sine angle incidence}}{\text{sine angle refraction}}$=index of refraction.
Then from any treatise on physics we will take the formula

$$\frac{1}{p}+\frac{1}{d}=(m-1)\left(\frac{1}{r}+\frac{1}{r^1}\right)$$

No. 1. For parallel rays the object is at any definite distance $\therefore d=\infty\ \frac{1}{d}=o$

Put $F=p\qquad \frac{1}{F}=\frac{1}{P}=(m-1)(\frac{1}{r}=\frac{1}{r})$

No. 2. Focal distance of parallel rays. For this case use symbol F instead of P

$$F=P=\frac{2r^1}{(m-1)\ (r+2^1}$$

r

No. 3. When $r=r^1$ $F=2\ (m-1)$

For glass used m varies from 1.52 to 1.56 equals about 1½. Hence p is equal approximately to v, or O F is nearly equal to C F. Since the rays of light intersect at O apparently we have from similar triangles $L\ T : L^1\ T^1 : : O\ R : O\ R^1$ letting $L\ T=b$ and $L^1\ T^1=i$.

No. 5. $b : i : : d : P^1$

$$\frac{b}{i}=\frac{d}{P^1}$$ or the relation of the size of objects to image varies directly with the distance from the object glass. To consider the case when objects shall equal image—in this case $b=i$ $\therefore$ $d+p^1$ and $\frac{1}{p^1}$ equals $\frac{1}{d}$ or $\frac{1}{p}+\frac{1}{d}=\frac{2}{p^1}$.

Hence from No. 1 $\frac{2}{p^1}=(m-1)\left(\frac{1}{r}+\frac{1}{r^1}\right)$ But in No. 2 we see this is the value of $\frac{1}{P}$ $\therefore$ $\frac{1}{F}=\frac{2}{P}$ or $F=\frac{P^1}{2}$ since p^1 equals d

No. 6. $F=\frac{P^1\ d}{4}$

Hence the principal focal distance is equal in this case to one-fourth the distance between object and image, as previously stated.

If the image shall be in linear dimensions ½ size of object, then $b=\frac{1}{2i}$ and substituting as before $f=\frac{2}{9}\ (P^1+d)$. If $b=\frac{1}{3}\ i$, $F=\frac{3}{16}\ (P^1+d)$, if $b=\frac{1}{4}$, $F=\frac{4}{15}$ (P^1+d). Or in general if n equal the ratio of object to image, we shall have

No. 7. $F=\frac{n}{(n+1)\ 2}\ (P^1+d)$, but since $n=\frac{d}{P}$,

No. 8. $F=\frac{P^1}{\left[\frac{d}{P}+1\right]2}\ (P^1+d)=\frac{d\ P^1}{(d\quad P^1)^2}\ (d\quad P^1)=\frac{d\ P^1}{d\quad P^1}$. Since P^1 is not separately known this last form is of little use. From No. 7 we see that when d is less with respect to P^1, n becomes correspondingly great, so that little error is made by omitting 1. Hence for distances exceeding 400 feet

No. 9. $F=\frac{P^1\ d}{n}$. Results must all be in same units. Correction for F to be deducted in case formula 9 is used.

Value P^1 d, feet.	Multiply F by No.	Value P^1 d, feet.	Multiply F by No.
25	.92	400	.995
50	.96	500	.996
100	.98	600	.9967
150	.98½	700	.9974
200	.99	800	.9975
250	.992	900	.9978
300	.993	1000	.9980

Since P^1 d is the distance from the image shown on the ground glass to the object, and on the ratio of object to image

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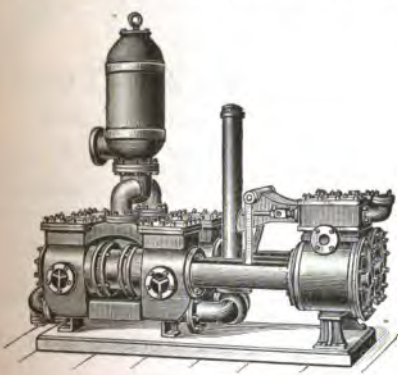

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From this we see that reckoned from the center of a picture on a horizontal line, distances divided by focal length gives us the angle either to the right or left. In the same way angles of elevation or depression can be found by measuring on a vertical line through the object as represented on the picture. If objects are not on these lines, the angles between their projectures on these lines will be the required ones.

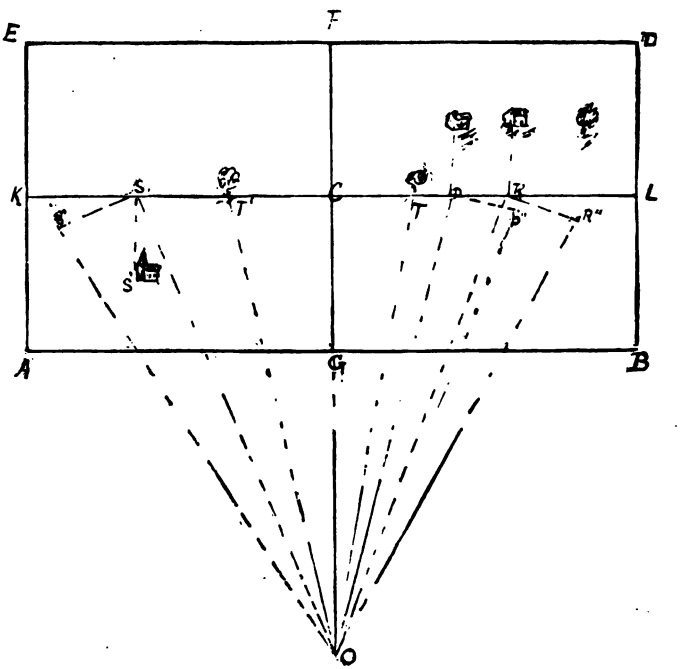


FIG. 8.

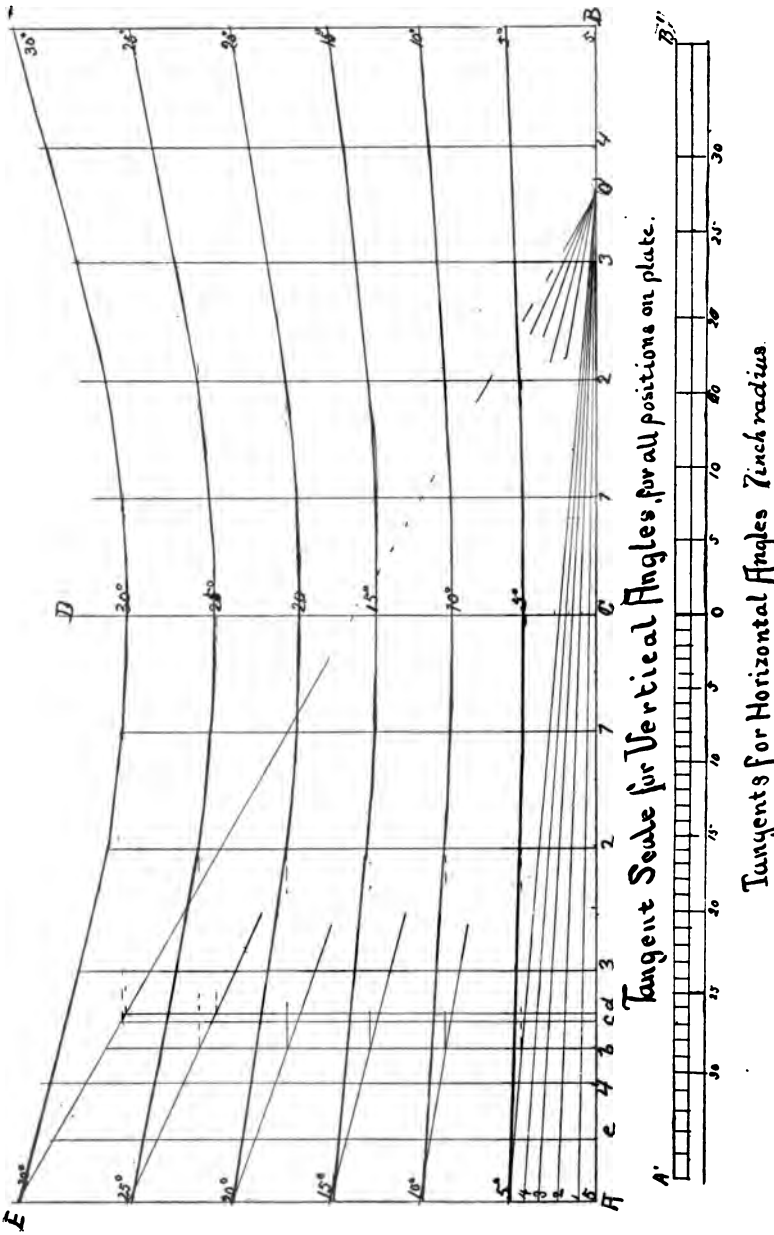
The actual process of reducing a photograph is explained by the above diagram, figure 8, which may be supposed to represent some of the prominent objects actually as they occur in the photograph. If the photograph is *A B D E*, the first thing to determine is the position of the horizontal line through the center of the picture. We will in this discussion suppose its position known, and draw this line on the photograph. Next determine the vertical line through the center of the picture, as *F G*. Their intersection at *C* is directly in line with the point of sight. Lay off from *C* in a vertical direction the distance *C o*, equal to the actual focal distance of the

lens; then will o be the horizontal projection of the point of sight. To find the angle between any two objects; first when in the horizontal line $R\ L$, as $T^1\ T$, draw lines from o to these points, then is $T^1\ O\ T$ the required angle. This may be measured with a protracter, or it may be computed, since it is the sum of two angles in the right triangles $C\ O\ T^1$ and $C\ O\ T$, whose tangents are respectively $\frac{T^1\ C}{C\ O = F}$ and $\frac{T\ C}{C\ O = F}$. If the objects are not in the horizontal line $K\ L$, as for instance $R^1\ S^1$, first project by a perpendicular into the horizontal line $K\ L$, R^1 will be projected at R, S^1 will be projected at S. Then is the angle $S\ O\ R$ the required angle which may be measured or computed as before explained. Tangent $S\ O\ C = \frac{S\ C}{F}$. Tangent $C\ O\ R = \frac{C\ R}{F}$. The angle of elevation of the object R^1 may be laid off and measured as follows: Project R^1 to R, draw $R\ O$, from the line $R\ O$ lay off $R\ R$ equal to $R\ R^1$ and in a direction perpendicular to $R\ O$. Draw $O\ R^{11}$ and the angle $R\ O\ R^{11}$ is the required angle. In a similar manner the angle of depression of the object S^1 is found to be $S\ O\ S^{11}$. These angles may be computed, since tangent $R\ O\ R^{11}$ is equal to

$$\frac{R\ R^{11}}{R\ O} = \frac{R\ R^1}{R\ O} = \frac{R\ R^1}{F^2\ \ T^2\ \ C\ R^2}.$$

Also line $S\ O\ S^{11} = \frac{S\ S^1}{F^2\ \ S\ S^2}$.

The work of reduction is thus seen to be comparatively simple. We must know, however, the accurate position of the horizontal plane $K\ L$ and of the principal vertical plane whose trace is $F\ G$. We must also know accurately the focal distance of the lens. The work of reduction may be much simplified by drawing on transparent celluloid a scale of degrees and half degrees for every portion of the picture. This can readily be done since T times $h°$ is equal to the length of n degrees measured on the horizontal or vertical line. Thus from a table of natural tangents multiply each number by the focal distance of the lens area, lay the distances off on the horizontal line from the center of the picture either way, for a scale of degrees. Suppose for instance $F=7$ inches, length of 1 degree on horizontal line equal to $7\times$ten $1°=7\times.01745=.12215$. Length of $2°=7\times.0349=.2443$, etc., up to the number of degrees within the limit of the field.


Tangent Scale for Vertical Angles, for all positions on plate.
Tangents for Horizontal Angles 7 inch radius.

Lay off these distances from O each way on the horizontal line A^1 B^1. Draw vertical lines through these divisions. This will then be a protractor which can be used for horizontal angles for all the work done with the lens in question, by making the center lines of the protractor agree with the corresponding lines on the photograph. The angles used will give the angular position of the object from the center of view. To make the protractor apply to vertical angles, lay off on the line C D the same diminsions as on the horizontal line. On A E and B F lay off tangents of angles multiplied by the square root of F^2 $\overline{C\ B}^2$, this brings the distance from the point of view to the edge of the picture, G or H.

Repeat the same operations for lines one inch apart between the edges and the center, the multiplier in this case being the square root of the focal distance plus the square of the width of the picture measured from the center. Draw lines through these points, which will be slightly curved, and these will be the measure of corresponding angles of elevation and depression.

To summarize the process, the tangent of any horizontal angle is equal, measured on the center line and from the center of the picture, to the distance on the picture divided by F the principal focal distance. Let a be the distance of the object to the right or left of the center and b be its height above a horizontal line; then tangent of any vertical angle is equal to $\frac{b}{\sqrt{F\ a^2}}$ The method of constructing this protractor for vertical angles is shown in the Figure 8. A B is a horizontal line through the center, C D the corresponding vertical line. Take any point as O^1 from which draw radiating lines any number of degrees apart, in this case 5° apart; these may be drawn by erecting a perpendicular one inch from O' and laying off the natural tangents of the required angles. This protractor being constructed for a lens of 7-inch focal length and for an 8x10 plate, the distance from principal focus to center, equals 7-inch distance, to 1-inch either side of center, and distance equals $\sqrt{50}=7.07$: to a point 2 inches either side $\sqrt{52}=7.28^1$; 3 inches either side $\sqrt{58}=7.69$, 4 inches either side $\sqrt{65}=8$. To a point, from point of view, at 5 inches from center $\sqrt{74}=8.6$. The products of the natural tangents of these various lines can evidently be obtained by drawing

vertical lines across these radiating lines at the required distance from *O'*, thus:—

At distance from *O'*, equal to 7 inches, erect a perpendicular, and where it intersects radiating lines will be the tangents for angles in the center of the plate. This in the figure is the perpendicular from *d*; project these intersections over on the line *C D*, and we have the value on that line of tangents of angles 5°, 10°, 15°, 20°, etc., as measured from the center of the picture. Next erect perpendicular from *C*, a distance 7.07 inches from *O'* and project points of intersection with radiating lines on to perpendicular from I. I, the lines being one inch distance either way from the center of the picture. Do the same for all other distances, draw curves through these various points, and we shall have a protractor for degrees applying to vertical angles above the center. This reversed on the line *A B* would apply below the center.

In using this protractor distances from the center of the photograph can be measured by means of dividers; applying these to the scale above and we shall have the angle from the center of the picture corresponding to the measured distance. Such a protractor worked up on transparent celluloid could be applied directly to the photograph and angles measured without the necessity of using the dividers.

CENTER HORIZONTAL LINE.

The method of finding the center horizontal line of the picture is of utmost importance, as on its position depends all subsequent work with the camera. The method I used was as follows: After carefully leveling the camera, I set up vertical rods by means of the Y level. I found where the horizontal plane of the center of the object glass intersected these rods, and at these points I nailed cross bars that could be plainly seen in the photograph. I marked the position of the image of these cross bars on the ground glass of the camera, turned the lens half way around and repeated the operation. The line found in both ways was coincident. Since that time I have found that a fine thread directly in front of the dry plate holder will be photographed, and I have now arranged two cross wires, one vertical, the other horizontal, that will be photographed in all my subsequent pictures for surveying purposes. With these lines in place and the camera accurately leveled, there will be little chance or opportunity for error, except such as comes from the instrument itself.

MEANS OF LEVELING.

My camera is mounted on a tripod, with leveling screws as used for a Y level. It can be leveled accurately and quickly and will remain where placed. It had a single swing back, but I found it the source of some errors, and, consequently, inserted scews to hold it rigid.

ADJUSTMENTS.

The principal and only adjustment required is that the image of the cross wires, when the instrument is level, shall be in the principal vertical and horizontal planes. The cross wires are best adjusted by an actual trial with objects known to be in the required planes. Once set they will be correct, for the camera is rigid and can not be inverted.

PRINTING PROCESSES.

The negative may be used to measure the angles from by laying the protractor on the glass. It is, however, an inconvenient thing to work from and liable to be broken or scratched. I would recommend some kind of a print.

BLUE PRINTING.

The simplest is the blue print process, and if a first-class special paper, as the Helios, is used, there will be no appreciable shrinkage. This process should be familiar to every one, as it is very convenient to duplicate tracings, and saves in that way untold labor. The chemicals used are—

Red prussiate potash, 1 part,
Citrate of iron and ammonia, $1\frac{1}{4}$ to $1\frac{3}{4}$ parts,
Water, 6 to 8 parts.

These chemicals should be dissolved separately and kept separate until needed. They can then be mixed and applied to the paper with a brush or a sponge. For printing from negatives a better solution will be had by using only about half as much water as given above. The chemicals can be applied by lamp light and the paper dried during the night; it must not be exposed to the light when dry. The writer discovered a queer property of blue print paper,—that if exposed to the light when wet it will turn light instead of dark. It will keep, however, a long time in a dry dark place. Any good linen paper can be used, but the best results are obtained on special paper made for this purpose.

For the purpose of printing, a frame, or some device, is necessary to hold the tracing or negative in close contact with

the sensitive paper. For the use of negatives, printing frames can be bought cheaply, and these would form a good pattern for larger frames for tracings.

Prof. Cleaves, of Cornell University, obtains excellent prints by clamping the sensitive paper and the tracing outside to a thin board. This board by means of a lever is sprung into a convex form with the tracing exposed. This makes a good contact and forms a cheap frame.

SILVER PRINTING PROCESS.

This is very complicated, and details can be had of any photographer; it is in fact the most difficult process in the art of photography. Albumen paper, which is ordinarily used, will shrink some and probably unequally; so it can not be recommended for this purpose. Aristotype paper is better in this respect, but so far as my experience goes, it runs very uneven and results are very uncertain. Arrowroot paper can be made nearly as readily as blue print paper, especially if one possesses a silver bath. It prints very quickly, gives detail without gloss, and is a rich dark brown, even if not toned. I have had good success with this paper, and give the method of preparing.

The formula I have tried is as follows:—

3½ parts arrowroot,
2 parts common salt,
100 parts of water.

The arrowroot is first dampened with water and mixed to break up lumps, then add remaining portion of water in a boiling condition. Dissolve the salt at any time.

To sensitize this, float on a silver bath, not to exceed 1½ minutes; a longer time will make the print gray. Fume with strong ammonia for 8 minntes, directly before printing; this will have the effect of making the prints bright, and darker.

Prints are made from this paper as from blue prints; it requires about 8 minutes exposure. They are then washed, toned and fixed as silver prints. The fixing bath consists of six parts of water and one part of hyposulphite of soda.

I feel that I have as fully described the process as the limits of this paper will permit, and with a few practical suggestions I will close. First, in regard to the size of camera. I purchased an 8x10 size, and I have found except for a few cases that a smaller size, for instance 5x8, would answer equally well. A plate 8 inches across is not much smaller than one 10 inches. Second, in regard to the kind of lens. I am fully satisfied that for this purpose, a lens of the wide

angled variety, rather than of the rapid rectilinear, is to be selected. You will need an excellent lens, aplanatic, one that is free from aberration, and the focal length ought to be nearly equal to the longest dimension of the plate. That is for a 5x8 plate use a lens with 8-inch focal distance; with an 8x10 plate use a lens with 10-inch focal distance. In either case the tangent of one-half the extreme angle covered by your plate will be .5, and the resulting angle = 54° nearly. So that in such a case the smaller plate covers the same field as the larger one, but the picture is to a smaller scale. The difference is in favor of the smaller plate for most work, because the instrument is more portable, more readily handled, and much cheaper in first cost.

In the wide angle type of cameras the diaphragms are of the rotating type and are fastened in the lens; consequently they are always in place and can never be lost.

A lens that covers 54° as an extreme angle will do accurate work probably over 45°, so that 8 views would be necessary to complete the horizon or to make a complete circuit of 360°. Usually two views will be all that is required at a station, as angles that on measure seldom exceed 90°.

The cost of a 5x8 photo-surveying outfit will be about as follows:—

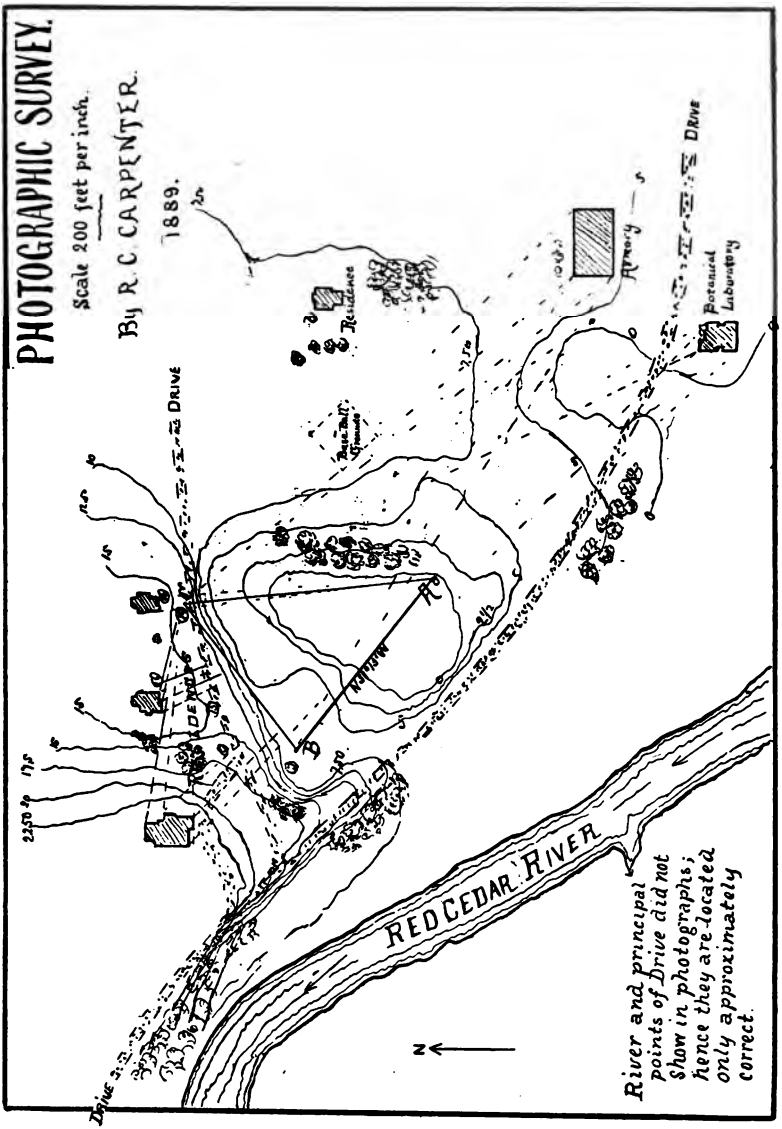
Lens,	$20.00 to	$40.00
Camera (no swing back),	5.00 to	15.00
6 Double Plate Holders,	9.00 to	12.00
2 Printing Frames,	1.00 to	1.00
Developing Trays,	1.00 to	1.00
Total,	$36.00 to	$69.00

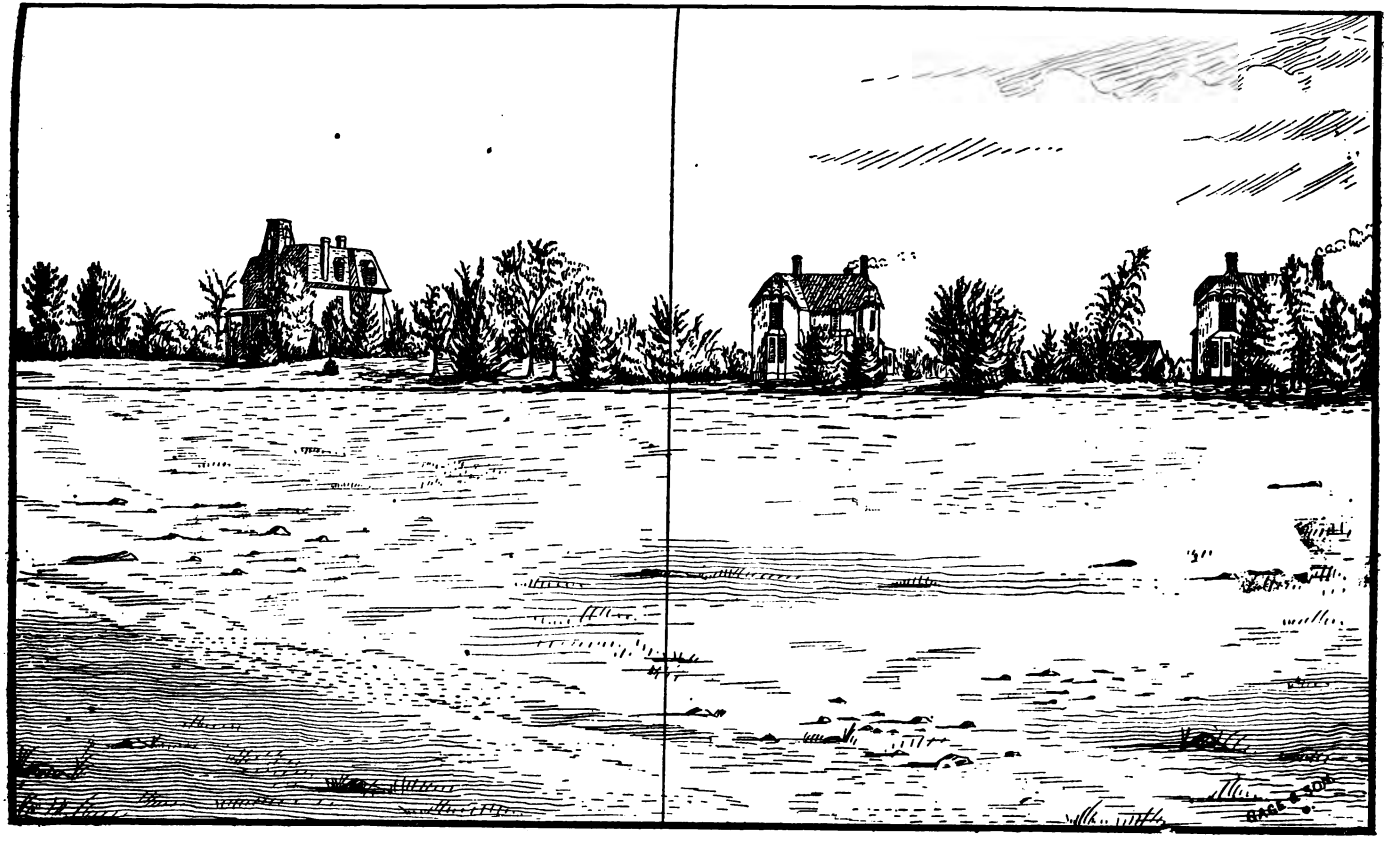
The above does not include a special tripod such as would be needed for surveying, nor does it include apparatus for silver printing. Sensitive dry plates 5x8 cost $1.25 per dozen.

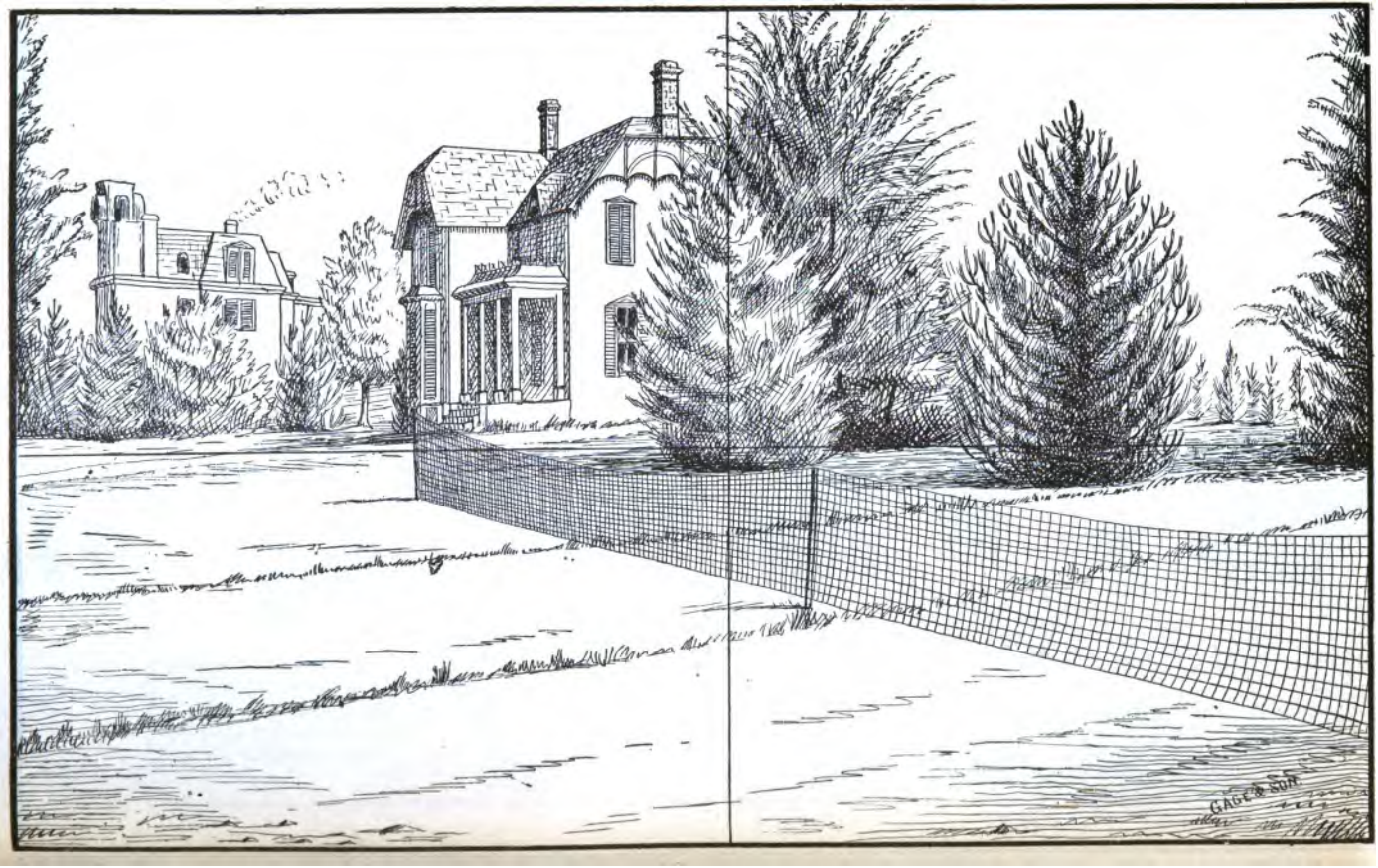
The cost of an 8x10 outfit, suitable for photo-surveying, will be as follows:—

Camera,	$ 8.00 to	$25.00
Lens,	30.00 to	50.00
6 Double Plate Holders,	10.00 to	12-00
2 Printing Frames,	2.00 to	2.00
Developing Trays,	2.00 to	2.00
Total,	$52.00 to	$91.00

This does not include tripod, nor silver-printing outfit. Sensitive dry plates 8x10 cost $2.40 per dozen.


PHOTOGRAPHIC SURVEY.
Scale 200 feet per inch.
By R. C CARPENTER.
1889.
RED CEDAR RIVER
Residence
Botanical Laboratory
Drive
River and principal points of Drive did not show in photographs; hence they are located only approximately correct.




GAGE & SON

The map which is presented with the article was worked up as follows:—

The distance from *A* to *B* was accurately measured with a steel tape and its bearing taken with a compass. The camera was then located at *A*, a station was established at *C*, and a photograph taken which includes both *B* and *C*. The camera was then moved to *B*, the other extremity of the base line. In order to include both *A* and *C* it was necessary to take two views, one view including station *A*, and the residence shown to the east side of the map, the second view, showing the same residence and station *C*. The instrument was then moved to *C*, and three views taken, one to the west, one to the north-west and one to the south-east. From the intersection of lines taken from these various photographs the accompanying map was drawn.

The writer regrets very much that time did not permit the production of a much more elaborate map. It will, I think, show the possibilities of photographic surveying. Two of the six photographs from which the map was constructed are reproduced; viz., the view from *A* including both *B* and *C*, and the view from *C* westward, showing intersecting lines.

R. C. CARPENTER.

In connection with Prof. Carpenter's paper, Mr. C. A. Stacey made an exhibit of the photographic stock manufactured and sold by the Eastman Company, of Rochester, N. Y., and demonstrated the manner of use. Mr. Stacey showed the workings of the Eastman system of film photography, by making a negative of the members in a group on a $6\frac{1}{2}$x$8\frac{1}{2}$ transparent film, which was developed on the spot. The developer formula used was as follows:—

No. 1.—*Pyrogallic Acid Solution.*—Pyrogallic acid, $\frac{1}{4}$ ounce nitrous or sulphuric acid, 10 minims; water, 16 ounces.

No. 2.—*Soda Solution.*—Sulphite soda (crystals), 3 ounces; carbonate soda (crystals), 2 ounces; water, 16 ounces.

To develop, take No. 1, 1 ounce; No. 2, 1 ounce; water, 2 ounces.

Fixing Solution.—Hyposulphite soda, 4 ounces; water, 16 ounces.

Mr. Stacey made several demonstrations with flash light and the "quick" bromide printing paper.

The Kodaks were placed in position (several sizes being used) and groups made by use of the flash light. The plates

or transparent film were cut from the roll holder and developed, and passed around among the audience.

The No. 4 Kodak, for 4x5 square pictures, has two finders, one for vertical and one for horizontal pictures, and a fine lens, made by Bausch & Lomb. This Kodak has an instantaneous shutter, which can be set for time exposures; also having rotating stops and adjustable shutter tension, two sockets for tripod screws, rack and pinion for focusing, and when it is loaded, weighing only four and one-half pounds.

The No. 3, for $3\frac{1}{4}$x$4\frac{1}{4}$ pictures, when loaded, weighs four pounds.

At the last evening session, printing and developing the "quick" printing bromide paper was done, making prints from the film negatives of the members which were made at other sessions, so that all could see the workings complete. The printing was done by electric light, also by daylight in a few seconds exposure.

We give below the formula for working the bromide paper.

The requisites for working bromide copying paper for copying drawings or plans, or making photographic copies of any suitable objects, are as follows:—

1 printing frame, of the required size, with glass.
1 glass graduate.
1 minim glass.
2 japanned trays.
1 pound oxalate potash.
1 pound proto-sulphate of iron.
1 pound hyposulphite of soda.
1 ounce bromide potassium.
$\frac{1}{4}$ pound citric acid.

Suitable bottles for contaning the solutions, and a supply of yellow post office paper.

DIRECTIONS.

No. 1.—Dissolve the $\frac{1}{4}$ pound citric acid in 1 quart cold water.

No. 2.—Dissolve the 1 pound oxalate potash in 3 pints hot water.

No. 3.—Dissolve the 1 pound proto-sulphate iron in 1 quart hot water.

No. 4.—Dissolve the 1 pound hyposulphite soda in 5 pints cold water.

No. 5.—Dissolve the 1 ounce bromide potash in 1 quart cold water.

Add to the oxalate of potash solution two ounces of the citric acid solution, and to the iron solution one ounce of the citric acid solution.

All the above solutions keep indefinitely.

Light for Operating.—Bromide copying paper is very sensitive to all white light, whether natural or artificial, and it is owing to this fact that it can be used for making photographic copies of any kind in a few seconds, by either daylight or lamplight.

To prevent the premature action of the light, it must be manipulated only in yellow or red light, to which it is practically insensitive.

To obtain such a light all that is necessary is to fit into the window of the operating room a cloth screen covered with yellow post office paper, or if the operations are to be conducted at night, a truncated cone formed of the same paper and placed over a lamp on the table will give the proper quality of light to operate by. The opening in the top of the cone should be just large enough to permit the heat to escape without scorching the paper.

To Make the Exposure.—We will suppose that the operator wishes to make a copy of a drawing or tracing, and that he is working by lamplight. Proceed as follows: Lay the drawing, face up, on the glass in the printing frame, and after putting the yellow cone over the light, open a package of the bromide copying paper and take out one sheet; lay it face down upon the drawing in the frame, fasten in the back and stand the frame in front of, and say fifteen inches away from the light, so it will fall evenly upon the glass, then raise the yellow paper cone and let the white light shine directly upon the drawing behind the glass. The proper time of the exposure depends upon the intensity of the light, the opacity of the drawing and the distance between the light and the printing frame. Working under the same general conditions, the operator will soon learn to judge accurately of the time required, but in the first instance it will have to be determined by experiment. The quickest way to arrive at the desired point is to partially cover the frame with a piece of card-board and make the exposure in sections, each one having a different period of time.

If the light is from an ordinary No. 2 kerosene burner and the drawing is on white bristol-board, with a distance of fifteen inches between the light and the printing frame, the exposure would be, say two minutes. For a trial give the first section exposed one minute, then draw the card to expose still more

of the drawing, and give one minute more, draw it still further and give another minute, and finally remove the card and give still another minute. The drawing will thus have been exposed in four sections, having respectively four, three, two and one minute exposures.

Replace the paper cone over the lamp, and taking the sheet of bromide copying paper from the frame, lay it in a tray and cover it with clean, cold water; while it is soaking prepare the developer.

The image formed by the light is invisible on the paper when taken from the frame, and has to be brought out by chemicals, called the developer.

THE DEVELOPER.

Take of the solutions prepared as before described, as follows:—

No. 2, oxalate potash solution, - -	3 ounces.
No. 3, proto-sulphate of iron solution, -	½ ounce.
No. 4, bromide potassium solution, -	1 dram.

Mix in the order given, and after pouring off the water from the paper in the tray, pour on the above. In about half a minute the paper will begin to turn dark where the light struck through the drawing paper, leaving the portions protected by the black lines white, thus producing white lines upon a black ground. When the exposure has been correct the lines will be pure white and the ground pure black. The developer should be allowed to act until the parts acted upon by the light are a deep black, then pour off the developer, and pour on, say one ounce of the citric acid solution. After allowing it to act a minute rinse the paper two or three times in pure water and then transfer it to a second tray in which there is sufficient of the hypo-sulphite of soda solution to cover it well; this is called the *fixing solution*, and it removes all the silver not blackened by the developer. After allowing it to act about five minutes return it to the first tray and wash it well for ten or fifteen minutes in running water, then pin it up to dry.

The Drawing.—To produce a good copy the *lines* of the drawing must be *strong and black*, so that when held up to the light no rays will pass through them. If the lines are black a good copy can be obtained from any drawing, whether on the thinnest tracing paper or the heaviest manilla. The only difference being the time required to print.

Uniform Illumination.—When printing by artificial light the distance between the frame and the light should be at least equal to the length of the frame to insure an even illumination.

To Make Non-reversed Copies, the *back* of the bromide copying paper should be laid against the face of the drawing. When making exposure for non-reversed copies hold the frame as far as convenient from the light to get the rays as near parallel as possible; this will increase the time of exposure as the square of the distance. Allowance should also be made for the fact that the light must pass through both the drawing and the bromide copying paper. For instance, say we have to copy a patent-office drawing on heavy white bristol-board. The time of exposure, if the drawing and bromide copying paper are face to face (making a reversed copy), will be about two minutes, fifteen inches from a No. 2 kerosene burner. If the back of the paper is laid against the drawing, the exposure at same distance will be one-half greater, viz: three minutes, while if the distance is increased to two feet to get a sharper image, the time will be eight minutes.

Daylight.—If the exposure is made by daylight the time will be much less, not more than one-fifth to one-twentieth, if made in front of an open window. In exposing by daylight care should be taken to avoid over exposure, by using a piece of straw board so as to cover and uncover the frame quickly.

Negatives and Positives.—A contact print from a drawing will be a negative, that is, the lines will be white and the ground black; if the negative is used to make a second print it will produce a positive or *fac simile* of the original. It is not necessary to dry the negative before making the positive. The piece of bromide copying paper for the positive should be soaked in water and laid, back down, upon a piece of glass or hard rubber, then lay upon it, face down, the wet negative and press them firmly into contact with a rubber squeegee, expose, separate and finally develop the positive as above directed. Negatives should have full exposure and long development to get as much density as possible, so that the positive will show a pure white ground with black lines.

Bromide Copying Paper may be used for copying plans, drawings, letters, documents, or printed matter of any kind by contact, when the matter to be copied is on one side only of the original. It can be used for making copies of leaves, dried or undried, for botanists' use. It can be furnished in rolls of any length or width for recording instruments in astronomical observations, etc., and it is available for many

other purposes where a sensitive paper that will keep both before and after exposure is desirable.

Hypo. Stains.—The hyposulphite of soda solution, if allowed to mix with any of the other solutions, will cause irregular black markings. The hands must be well rinsed after using it, to avoid stains on the paper.

Blisters sometimes appear in bromide paper, and may be avoided by using a little common salt in the first water after fixing. Dissolve two tablespoonfuls common salt in one pint water ; put the print into this as soon as it comes out of the fixing solution ; allow it to act one minute, then wash and dry.

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Copies of Drawings to Accompany Estimates should always be made on bromide copying paper, thus retaining all the good quality of the originals without the cheap look of blue prints.

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THE PLANE TABLE.

THIS is a surveying instrument in use for obtaining the very last details, and for topographical work. It is not very accurate, but will give uniform results, so that if the scale is small, or the results are not needed with too much accuracy, it answers a very good purpose. Years ago it was in use on the U. S. Lake Survey, but was abandoned and a transit and drawing board taken into the field in its stead, I believe. This was because the men on the survey were not pleased with the trustworthiness of the results obtained. As you are aware, this instrument consists of a drawing board mounted on suitable devices for putting and keeping it level. On this board is stretched a piece of paper, and a map of the work is carried forward as the work progresses. In connection with the plane table there is always used an alidade. This alidade is nothing but a rule or straight edge, and a line of sight. The line of sight may be the edge of the rule, or be defined by a pair of compass sights or a telescope. All that is necessary concerning this line of sight is that it should range in a plane perpendicular to the under side of the rule. In order to make the adjustment easy it is customary to make this line of sight range, or revolve, in a plane parallel to the edge of the rule, as well as perpendicular to its under side. It seems as though the plane table would solve some problems not possible with the transit, because of the map being combined with the instrument, but such is not the case. One of the more notorious of these problems is the Two-Point Problem of the books. This can be solved by the transit as well as with the plane table.

I shall be more particular to mention those things not to be found in books. By the books one is instructed to set the plat of a point on the table over the point on the ground which it represents. There is provided and sold a sort of a U for the purpose of plumbing down from the point on the table to the point on the ground. But with the aid of all the devices to be obtained it will be a mere chance if when the table is set the point on it is over the point on the ground which it represents. The reason of this is that the table must be set always parallel to its first position on the survey, and so it occurs that when it is set so the point on it is over the point on the ground which it represents, the first thing to be done is to turn it slightly from this position in order to orient the table, that is, set it parallel to its first position, and so destroy the relation of the two points which was so carefully obtained. This is to be considered a vital defect in the use of the plane

table and no doubt it has led to the abandonment of its use in numerous instances. This defect I remedied some fifteen years ago or more by setting the table central over the point of observation with a plumb bob just as a transit is set. I find by reference to my class records that I was giving instruction in this manner of using the plane table in 1875. There are required for use with the plane table when operated in this manner two triangles. These are carried instead of the U-shaped tool before named. The plumb bob is hung at the center of the instrument as in any case. It is also necessary to find the center of the sheet of paper on the drawing board, that is where the spindle axis of the board will pierce the paper. This may be very easily done for each sheet of paper but a much better way is to do as follows: Fix some sharp pointed tool, like a knife or a needle point rigidly, so it will barely scratch a fine mark on the face of the board when it is turned on its spindle under this fixed point. By these means scratch the circumference of a circle, or parts of one, on the face of the board. Make sure it is nicely and precisely done. Construct the center of this circle. It will be the center of the board as above described. Set in a piece of brass flush with the face of the board so that a hole in it of a suitable size to admit a common pin will mark the center permanently. Whenever a new paper is put on the board a little search will enable a pin to be pushed through the paper into the hole in the brass where it should fit and be left standing for convenience in using the board. By this arrangement the alidade, which, as usually constructed, is of considerable weight, will always stand central on the board and not near its edge. This will give increased steadiness and stability. To illustrate the manner of using the plane table in this case I will describe a few of the operations necessary to start a survey, well knowing that when that is done the work can be followed out readily. Take the plane table to the first point of the survey or to the place where it is to begin. Set it over the point just as a transit would be set with the plumb bob from its center and over the point. Observe to set the table so low that the edge of it will come at the bend of the body just below the hips of the person who uses it. This is necessary to make the working of the table convenient and to prevent liability of resting the weight of the arms or some part of the body on the table, which must not be done. All beginners are apt to set the table far too high. Next clamp the spindle of the table so it will stand in a position suitable for receiving the work to go on it with reference to the point it stands at, remembering that

always after this it must be set parallel to this, its first position. Place the alidade central on the table with its level tubes parallel to the pairs of leveling screws below. Carefully level the table. It is now ready for use. To begin observations to other points of the work, first choose which hand the rule of the alidade is to be used on, that is make a choice of which side of the lines observed along, with references to the observer, either to his right or to his left, the rule shall be set. Having made this choice it must be continued throughout the work, to avoid introducing the errors of some of the adjustments into the work. It is well for a right-handed person to use the rule on his left of the lines and on the right for a left-handed person. This must be continued to be done when looking along any line in either direction. Having made this choice, place the work edge of the rule of the alidade gently against the pin in the centre of the sheet, and with the hands, sliding the alidade on the paper but always keeping it up to the pin as noted, bring the line of sight on to the line to be observed and leave it carefully set there. Choose the place on the paper where the plat of the first point of the survey shall be and prick it down with a needle point or note it precisely in some way. Place one of the triangles against the rule and the other triangle against the first named so the first named can be slid over the paper and have its edge that was placed against the rule pass through the chosen point. Make the transfer of the line from the rule to the point and draw the line on the paper through the point. Slide the triangle back to the rule and make sure there are no slips. See if the line of sight still stands on the line it was set on. If these checks show errors, review the operations and correct them. These operations can be repeated for any number of points or lines. Finally before taking the plane table to a new place, try the position of the table by the first line laid down on it. To do this, set a triangle to this first line as it is drawn on the paper and slide it over to the center of the sheet. Grasp the alidade firmly and set it by the edge of the triangle at the center of the sheet so it—the rule—will still stand parallel to the line. See if the line of sight strikes the first line of observation. It may not fit with great precision,—this is not to be expected,—but a little experience will show when it will be necessary to review the work. By these means make sure of the stability of the table during the observations. Having done this the table may be carried to the next point of the survey and set up and leveled as before, except now there will be no use in trying to set it by estimation in position

only in a general way. After it is leveled, slide the line from the plat of the point at which the table stands to the plat of the point from which it came, over to the center of the sheet and set the alidade by it as before described for testing the stability of the table at the last point. Be sure to keep the rule on the *same hand of the observer, not* on the same side of the line. Having set the alidade as above noted, slide the triangle back to the line and see there are no slips. By means of the clamp and slow-motion screw to the spindle, set the line of sight on the point from which the table came. Now, the table is said to be oriented, that is, it stands parallel to its first position. Observations may now be made as at first. They may be continued at will, but observe to test the stability of the table, and the quality or correctness of the work and the various observations connected with it so frequently that the result obtained may always be received with confidence that they are as good as the plane table will give.

For the methods of determining the positions of points, and the various plans of conducting a survey, the text books on surveying may be consulted. For this purpose see Gillespie, new edition. Johnson gives a little about the plane table, but there is a more complete work entitled The Plane Table, from the papers of the U. S. Coast Survey. No trouble will be found in adapting the processes given in these books to the method of setting the center of the board over the point of observation in the regular way of using other instruments, and better results will be got with greater ease, comfort and speed.

With the plane table goes its plumb bob, the alidade, the triangles, a scale, three-legged dividers for transferring points, hard pencils, erasers, pocket knife, thumb-tacks in plenty, a little compass box made for this especial service (sometimes this is on the rule, but better be separate), and a large piece of rubber sheeting or light rubber cloth of a size to envelop the table and all there is on it, and tack under the board, to secure the drawing and the various things from the rain or dust as occasion may require. There may be a place made under the board to keep the triangles, the scale and some of these things in.

The telescope on the alidade may have a vertical circle, a level on the telescope tube, and be fitted with stadia cross wires. These devices are all well described in books, and will be found of service in much plane table work. The stadia may be used for measuring heights and distances roughly for topography. The distances in good stadia work compare well

in precision with the common chaining before the day of the steel tape. Hence it is quite good enough for topography. I mention these things to call attention to the fact that the stadia will measure a designated distance, and, with the vertical circle, a designated height and distance, but that it cannot be used to set out, lay off, or measure, a given height or distance,—as 745.14 feet. It solves but half the problem. This is the simple—and sufficient—reason why it has never come into more general use. No one should attempt to lay out work with a stadia, unless ready to part with his eyes, as all experiences of this kind, within my knowledge, show that this will be the result very shortly. The stadia is so frequently used with the plane table that I deem this word of caution necessary.

The determination of the sides and angles of a triangle with a plane table presents all the difficulties or peculiarities of plane table work, except in one case, that of determining a fourth point from three others, known as the three point problem. What appear in the books to be more than this really are not. The three-point problem having been much discussed and elaborated, especially in former times, I will suggest still another solution of it that will be found convenient for use on the plane table. This solution is entirely mechanical and requires no rules, or equations, or geometry. This is the three-point problem: Knowing the location of three points, that is they are platted down on the plane table, the position of a fourth point may be determined by setting an instrument at this fourth point and observing the angles between lines from it to the three given points. To do this, set the plane table at the fourth point, without attempting to orient it, dampen it, and draw three lines by the rule from the center of the sheet running to the three given points. An extra piece of paper may be put on over the sheet if desired for this purpose. Fit the three-legged dividers with one foot on the plat of each one of the three given points. Notice which way from the three given points on the ground the fourth point, at which the table stands, is. Fit the three-legged dividers, carefully set as above noted, on to the three lines drawn toward the three points from the center of the sheet, so the center of the sheet, which represents the fourth point, will be in its relative position with respect to the three feet of the dividers. Make the adjustment with precision. Now prick down the three points on the three lines, and these, with the center of the sheet, will show the relative position of the four points on the ground to the scale used. Set the

three-legged dividers on two of these and the center of the sheet. Place the two feet on the plats of these two points on the map and prick down the plat of the fourth point with the third leg. It may, of course, happen that the plats of the three given points cannot be spanned with the three-legged dividers. This is easily met by reducing the distance between them by the same ratio, and thus obtaining three points the dividers will span. Then solve the problem with these three, and the resulting four point figure will be too small by just the ratio of reduction used.

For all such work a pair of three-legged dividers of considerable size is needed, having the third leg sliding in a sleeve with a clamp, so it can be set at any length within the limits of the piece.

I solved the problem in this way at about the time mentioned above as the time when I began working from the center of the sheet. There are six possible solutions. Three of these are easily traced out by trying the experiment. The other three might be missed, and are to be found by turning over the paper on which the three lines are drawn, and applying the dividers to the back side of the paper. I also tested the solution in the special cases, and when the four points are on the circumference of a circle. I examined all these results to see if there was anything in them likely to confuse the operator. There was not. Be sure to notice which way from the three given points the fourth one is, and apply the dividers to the three lines accordingly. That is all.

The ordinary problems in surveying I solved many years ago with the plane table. Some of these are laying out circular curves, parabolic curves, finding the azimuth of a line astronomically, and the like. But these things are of the nature of curiosities or extreme exceptions, and are much better done with other instruments.

In taking charge of any instrument for the first time, look over even the simplest matters, and see that everything is in order from the ground up. From that on, these matters constitute a part of the operator's general care. This is especially true of the plane table. See that the shoes at the bottoms of the tripod legs are tight, and do not rattle. See that the legs work tight enough at the cap. See to the tripod head and its connection with the board. See that the arms under the board are tight fast to it; that the board itself is flat and square to the spindle. See that the rule is straight, and the two edges of it parallel, so one may slide off lines from either edge.

Plane tables are sold from $150 to $350. The great point to be considered is steadiness of the table. I have never been informed why these instruments are charged for at the rate they are. The prices seem very high to me. The board should be of dry, soft, even, straight grained pine. The same defects of construction attend these instruments that do others. The clamp on the vertical circle is bad, and many other similar defects are to be found.

I will conclude by giving, in a compact form, the adjustments of the plane table.

1. See that the edge of the rule is straight by testing it on a fine pencil line, and correct it if need be. Also see that the two edges of the rule are parallel by drawing fine lines by each edge, and testing them with the dividers.

2. See that the surface of the board is a plane, by testing it in all directions with a straight edge, and working it down, if need be, with a smooth plane, a scraper, or sand paper.

3. Levels on the rule.

Set up the board and level it.

Draw a line by the edge of the rule, and mark the place of the ends of the rule.

Remove the alidade and replace it on the board on the opposite side of the line, just fitted to it, and the ends of the rule at their marks.

See if the bubbles show level.

If not, reverse the alidade back again and make a few reversions till satisfied the bubble tubes are out of adjustment.

Leave the alidade so as to show the error.

Correct one-half the apparent error by means of the screws that hold the tubes to the rule.

Test the adjustment as at first.

Repeat the tests, corrections and tests till no error appears.

4. Board square to spindle.

Set the plane table and level it with the alidade central.

Reverse the table on its spindle.

See if the bubbles still read level.

If not, reverse back, and by repeated reversions make sure if any error exists.

Leave the table so as to show the error.

Correct one-half the apparent error by inserting wedges between the arms and the board, beneath it.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

Having the board thus properly set, replace the wedges by suitable washers or other devices of a permanent and durable kind, and finally fit these so that the above described test shows no error.

5. Line of sight at right angles to telescope axis.

Set up the table and level it with the alidade central.

Find two points in apparent line and clamp the spindle with the line of sight set on them.

Reverse the telescope carefully on its axis and find a point in apparent line in the opposite direction.

Reverse back again, and by repeated reversions make sure the table and alidade are steady.

Lift up the alidade, change ends with it, and replace it on the table in a reversed position with great care. Set the line of sight on the two first named points, for which purpose the spindle slow-motion screw may be used, if need be.

Reverse the telescope on its axis and see if the third point is in line.

Reverse back again, and by repeated reversions make sure the table and alidade is steady.

Leave the telescope looking at the third point, so as to show the deviation of the line of sight therefrom—or the error.

Correct one-fourth this apparent error by moving the cross-wires by means of the screws that hold them in the telescope tube.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

The above directions apply to a telescope that can be reversed. In case it cannot be reversed, the wyes must open and then the line of sight adjustment be made by pointing on any point; lifting the telescope out of the wyes; turning it over; replacing in wyes, same end towards point; seeing if line of sight now strikes the point; correcting one-half the apparent error by the cross-wire screws, and testing, and correcting and testing till no error appears.

6. Adjusting telescope axis vertically.

This makes the line of sight revolve in a plane, perpendicular to the under side of the rule.

Set up the table as near some high, well-defined, fixed point as it can be, and that point be observed through the telescope with the alidade central on the board. Place the alidade central on the table, and level it carefully.

Set the line of sight on the high, fixed point, by means of the spindle clamp and slow-motion screw.

Turn the objective downwards, till the line of sight points at nearly the same angle below the horizon that it did above. Find or take two points near by in apparent line, ten or fifteen feet apart, with little or no change vertically in the pointing of the telescope.

Make sure of the stability of the telescope, by repeated pointings upon the upper and lower points.

Reverse the alidade and the telescope on its axis. Set the line of sight so as to range upon both lower points, using the spindle clamp and slow-motion screw.

See if the upper point is in apparent line. Repeat the pointings, to make sure of the stability of the telescope. Leave it looking at the upper point, so as to show the error.

Correct one-fourth the apparent error, by means of the device provided for controlling the inclination of the telescope axis to the horizon.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

7. Adjusting the telescope axis, horizontally.

This makes the line of sight revolve in a plane parallel to the edge of the rule.

Provide a firm, level support for the alidade. Two stout, square-topped stakes properly driven may answer. This support may be leveled by the alidade. The cross level is the more important, but both should be level. From this support the line of sight should strike a distant, well-defined, fixed point. Have ready a needle, needle point, or a similar tool. Put a paper on the table.

Set up the table about 20 feet from the alidade support and on line from it to the distant point. Level the table carefully and clamp the spindle securely.

Place the alidade on the prepared support. Set it level by bits of wood, or the like, when its line of sight strikes the distant fixed point.

Locate two points in line on the table with the needle point a little less than the length of the rule apart. Also locate a point in line 40 or 50 feet beyond the table.

Transfer the alidade forward, as it stands, to the table with the edge of the rule at the points located on it.

See if the distant point and the near point are now in the range of the line of sight, or both the same distance therefrom on the same side.

By means of the device for controlling the angle of the telescope axis with the edge of the rule, set this axis so the line of sight will strike the points named, or pass the same distance from and on the same side of both when the alidade sets on the line of the points on the table.

After the adjustment seems perfect see that the table has not been moved, by trying the line of all the points again from the alidade support.

In making this adjustment the alidade may be set over parallel to the line of the two points on the table, by pricking off equal spaces from them, so that, after sufficient trials, the line of sight will strike both points when the telescope axis is adjusted. This saves any estimating of the distances the two forward points are from the range of the line of sight.

8. Center of the board. Given on a previous page in the first part of the description of the use of the plane table.

9. Vernier to vertical circle. Adjusted the same as on a transit instrument.

10. Telescope level tube. Adjusted the same as on a transit instrument.

In the case of the 9th and 10th adjustments the alidade should stand central on the board, and close watch kept and frequent tests applied to be sure of the stability of the apparatus during the work of adjustment. J. B. DAVIS.

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SUPREME COURT DECISIONS.

The following abstract of Supreme Court Decisions rendered during the past year, is taken by permission from the American Digest, published by the West Publishing Co., St. Paul, Minn.:—

1. Where an inland non-navigable lake covers a portion of a section of land, and the Government survey designates the dry land in each subdivision as a fractional subdivision or lot, the purchaser from the Government of such lots acquires title to all that portion of the bed of the lake included in the whole subdivision.—Stoner v. Rice, (Ind.) 22 N. E. 968.

2. Where the patentee of "the north half of the south-east quarter, and that part of the north-east fractional quarter, of section 36," etc., "which lies north of the Kankakee river, containing in all 122.70 acres," conveys "the north-east quarter of section 36," etc., "containing 122.70 acres," the deed passes title to all of the land in said north-east fractional quarter lying south of said river.—Sphung v. Moore, (Ind.) 22 N. E. 319.

3. A patent for a fractional quarter section, which is bounded by a meandered stream, passes title to all land within the lines of said quarter section between the meandered line and the water's edge.—Sphung v. Moore, (Ind.) 22 N. E. 319.

4. Where two deeds in plaintiff's chain of title respectively define the boundary of the land "by the edge of the mill-pond," and as "the bank of said mill-pond," and defendant is entitled to pond as much land as the pond flowed at the time of his purchase, defendant may enter on land originally covered by the pond, but which has subsequently become dry land by the receding of the water, though plaintiff's deed on its face shows his line to be the center of the pond.—Holden v. Chandler, (Vt.) 18 A. 310.

5. The owner of land on a bay conveyed an acre at the end of the tract nearest the bay, described as follows: "Beginning * * * by the beach, running * * * along the beach to," etc. In the general description of the tract it was bounded "easterly by the said beach." The grantee was given the privilege of a road from the middle of the front of the lot to the bay, and also half the drift coming on shore in front of the lot, and all the other privileges of the beach were reserved by the grantor, who bound himself not to build any house in front of the lot. The courses and distances would not carry the boundary to high-water mark. *Held*, that the beach did not pass by the deed.—Benson v. Townsend, 7 N. Y. S. 162.

6. Where a deed conveys land "bounded and described according to" a certain survey, does not call for a river, but calls for a line run between certain points, designated by the surveyor as on the bank of a navigable river, and it appears that the lines of such survey exclude flats between high and low water marks, evidence *aliunde* is admissible that the bank referred to was an artificial dike; that the grantee had notice that the grantors reserved the flats; that the grantors refused to execute a deed expressly conveying the flats; and that the sale was expressly subject to the survey, as tending to show that the flats were excluded, whatever may be the presumption from the deed.—Palmer v. Farrell, (Pa.) 18 A 761.

7. A complaint was filed to quiet title to 150 acres of land lying on the south side of a fractional section. A surveyor was ordered to survey that quantity, to be taken the full length of the section from the east side thereof to a river as the western boundary, and extending far enough north to include 150 acres. The surveyor executed the order, and reported a survey, which was accepted, and the court entered judgment, wherein the land was doubly described by inconsistent descriptions. The first described it as in the order of survey, and the second by metes and bounds, by which, after beginning at the south-east corner of the section, and following the south line to the river, it ran up the river, with the meanders thereof, to a stake placed by said surveyor 19⅓ chains north of the south line of the section; thence running westerly, parallel with the south line, 53.04 chains, to

a stake in the east line of the section; and thence southerly with said line 9⅓ chains, to the beginning. The stakes were gone, but were shown to have been placed at points 19⅓ chains from the south line, thereby including 150 acres. *Held*, that the first description should govern.—Caspar v. Jamison, (Ind.) 21 N. E. 743.

8. Rev. Stat. U. S. § 2396, provides that "the boundaries and contents of the several sections, half sections and quarter sections of the public lands shall be ascertained" as follows: "All the corners marked in the surveys returned by the surveyor general shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate; and the corners of half and quarter sections not marked in the surveys, shall be placed, as nearly as possible, equidistant from those two corners which stand on the same line. * * Boundary lines which have not been actually run and marked, shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships where no such opposite corresponding corners have been or can be fixed, the boundary lines shall be ascertained by running from the established corners * * * to the water-course," etc. *Held*, that in surveying a lot bordering on a river the water-course becomes the boundary, and continues so, no matter how much it shifts by accretion, and conveyances of the lot pass all, including such accretion to that line.—East Omaha Land Co. v. Jeffries, 40 F. 386.

9. The facts that rapid changes in the banks of the Missouri river are constantly going on, and that 40 acres have been added to adjoining land, do not overthrow an averment of a bill to quiet title to such addition, on the ground of accretion, that it was by an imperceptible increase, where it was nearly 20 years in forming. —East Omaha Land Co. v. Jeffries, 40 F. 386.

10. Where a deed describes a lot conveyed as of a certain width, and a party-wall stands on the south line, the north line may be found by measuring the given distance north from the middle of such wall.—Warfel v. Knott, (Pa.) 18 A. 390.

11. Where the probate judge, in pursuance of the provisions of Sess. Laws, Colo. 1872, p. 191, relating to town-site lots in Denver, advertises and sells a lot bounded on an unnavigable stream, and on the same day, and as part of the same sale, sells the bed of the same stream to another person; the deeds for the two parcels being executed the same day, and containing the same recitals,—the intention thus shown to separate the ownership of the bed of the stream from the ownership of the lot will overcome the presumption that a deed to a lot bounded on an unnavigable stream carries the title to the bed of the stream to its center.—City of Denver v. Pearce, (Colo.) 22 P. 774.

12. An instruction that, in arriving at a boundary line as originally run, natural objects are controlling calls; artificial objects, second in importance; course, third, and distance, fourth; and that, where there is still uncertainty, that rule should be adopted most consistent with the intent of the grant, is correct.—Luckett v. Scruggs, (Tex.) 11 S. W. 529.

13. An instruction that the beginning corner of a survey is of no higher dignity or importance than any other corner, and that, "if there are well-known and undisputed original corners established upon the ground around the survey, they would control the other calls of the survey, which are conflicting and contradictory, if there are any such," is correct.—Luckett v. Scruggs, (Tex.) 11 S. W. 529.

14. Where neither the corners of plaintiffs' nor defendants' land are satisfactorily established, and there is a well-established and identified corner of another survey, from which, by following course and distance, defendants' survey can be constructed, such course should be followed, though the boundaries thus established include land within the boundaries of plaintiffs' junior survey.—Griffith v. Rife. (Tex.) 12 S. W. 168.

15. Where the beginning corner of a survey is the south-west, but the south-east corner is equally well identified, a charge limiting the jury to finding the unidentified northeast corner by the first and second lines from the south-west

corner, is erroneous, as the south-east corner is of equal importance, unless the line from the former corner was actually run and measured, and that from the latter not.—Scott v. Pettigrew, (Tex.) 12 S. W. 161; Lancaster v. Ayres, Id. 163.

16. An instruction making the importance of an established north-east corner, in locating the north and west lines of a survey, dependent upon the jury's belief that such western line was not run, is erroneous, as such corner has the same weight for the purpose in question, whether the western line was run or not.—Scott v. Pettigrew, (Tex.) 12 S. W. 161.

17. In the description of lands, as to questions of boundaries the rule is settled in Virginia and West Virginia that natural land-marks, marked lines, and reputed boundaries will control mere courses and distances, or mistaken descriptions in surveys and conveyances.—Gwynn v. Schwartz, (W. Va.) 9 S. E. 880.

18. The statement of the quantity of land supposed to be conveyed, and inserted in deeds by way of description, must not only yield to natural land-marks and marked lines, but also to descriptions in deeds by courses and distances.—Gwynn v. Schwartz, (W. Va.) 9 S. E. 880.

19. A call for a lot by the name or number which it bears on a plat of the land will prevail over courses and distances, and ordinarily over calls for monuments.—O'Herrin v. Brooks, (Miss.) 6 So. 844.

20. Where the descriptions in a deed refer to a survey and a map based thereon, making both a part of the deed, and there is a discrepancy between the map and the survey, the latter will prevail.—Whiting v. Gardner, (Cal.) 32 P. 71.

21. When a survey calls for the "Dougherty" survey as one of its adjoiners, an instruction that if the jury find that the "King" is the survey intended by the call for "Dougherty," the former being located, the call would furnish "some evidence" of the location of the survey in question, is insufficient, as such a finding would locate the survey in the absence of marks upon the ground.—Tyrone Min. & Manuf'g Co. v. Cross, (Pa.) 18 A. 519.

22. Where no marks are found on the boundaries of a survey, and it cannot be located on the ground, evidence of the location of junior surveys which call for the lines of the elder as adjoiners is admissible, as showing where the surveyors upon the ground located such lines.—Tyrone Min. & Manuf'g Co. v. Cross, (Pa.) 18 A. 519.

23. Where the court, in an action of ejectment, instructs the jury that, "after a survey of blocks had been returned and had remained in the land-office 21 years, it was conclusively presumed that it was run upon the ground, whether marks were found upon the ground or not," but in other portions of his charge repeatedly states the law to be that marks made by the surveyor on the ground are the first and highest evidence of the true survey, the instruction cannot, on the whole, be said to be misleading, as he will be reasonably understood to have charged that the presumption in favor of returns of surveys on file for 21 years is only applicable to such surveys where no monuments or marks on the ground are found to contradict them.—Grier v. Pennsylvania Coal Co., (Pa.) 18 A. 480.

24. The monuments or marks of the surveyor on the ground determine the true survey as against calls for adjoinders or courses and distances as returned; but, each block of surveys being separate and complete of itself, the call of a tract in one block for an adjoinder in another does not make the monument of the adjoinder the monument of the later block.—Grier v. Pennsylvania Coal Co., (Pa.) 18 A. 480.

25. Where a boundary line is assented to by the owner of a tract of land at a time when there is no dispute concerning such line, and on the supposition that it is the true boundary, he is not estopped, on discovering that such is not the case, from claiming title to the real boundary.—Schraeder Min. & Manuf'g Co. v. Packer, 9 S. Ct. 385.

26. Continuous and uninterrupted possession, under claim of ownership, to the line of a division fence, will not bar title, where it appears that such occupa-

tion was under a belief that the fence was on a true line, and without intention of claiming beyond the true line, as described in the deeds.—Skinker v. Haagsma, (Mo.) 12 S. W. 659.

27. Where a survey is referred to in a deed for greater certainty, it legally forms a part of it and both should be construed together.—Heffleman v. Otsego Water-Power Co., (Mich.) 43 N. W. 1096.

28. An exception in a deed which reads, "Except the dower of fifty acres, as fully described in the deed given the C. B. Co.," is not void, though the boundaries of the excepted land are not defined in any way, as reference may be had to the deed to the C. B. Co. to ascertain them.—McAffee v. Arline, (Ga.) 10 S. E. 441.

29. The exterior of two adjoining interior surveys were undisputed. The boundary line between them had never been surveyed, but its southern end was marked by an oak. North of these surveys were two others. These four surveys were originally returned as being of equal size, and having one common corner. The northern end of the line between these two latter surveys was marked by a sugar-maple; which was not directly opposite the oak, and it was proved that the northern line of these surveys was shorter than the southern line of the others. *Held*, that the boundary line between the two southern surveys should run from the oak parallel to the end lines, and not diagonally from the oak to the maple. —Bloom v. Ferguson, (Pa.) 18 A. 488.

30. The course of the eastern line of the H. tract, as given in the original survey made in 1745, was 14 deg. east. The course of the western line of the B. tract, lying immediately east of the H. tract, as given in the original survey made in 1813, was 17 deg. and 15 min. east. The western line of the B. tract was made of exactly the same length as the eastern line of the H. tract, and the beginning point of the two lines was the same. The difference in the course of the two lines could be satisfactorily explained by the change in the position of the magnetic needle which had taken place in the time intervening between 1745 and 1813. *Held*, that the two lines must be considered as coincident.—Scott v. Yard, (N. J.) 18 A. 359.

31. The owner of a lot in the city of Rochester, of the area of about one-half acre, rectangular in form, fronting 274 feet on a street, and abutting on the rear for the same distance on a canal, the location of both, as well as the other lines, being undisputed, conveyed a portion, by description, of "137 feet front and rear, measuring from G. H.'s north line on G. street, and also 137 feet from G. H.'s south line on the canal; being the piece of land occupied as a garden by the grantor." The lot was divided by a fence, one side being used as a garden; the fence starting on G. street midway, but striking the back line at the canal at a point 19½ feet from the middle of the lot. That fence was not mentioned in the deed. *Held*, that the reference to the garden was too indefinite to control the calls for exact distances from known bounds, and the divisional point on the canal should be located 137 feet from G. H.'s line.—Harris v. Oakley, 7 N. Y. S. 232.

32. Plaintiff owned a village lot, No. 124, and a tract of land lying adjacent thereto on the south and east sides. River street, which lay along a river's edge, was the westerly front of both the lot and the tract. He conveyed the tract to defendant, reserving a part thereof, beginning at the S. W. corner of the lot; thence south-easterly, along River street, 32 feet; thence north-easterly, "on a line with the S. E. corner of lot No. 124," 10 rods and 23 links; thence N., to M. street; thence W. to the N. E. corner of the lot; thence south-westerly, to the S. E. corner; thence to the beginning. Locating the beginning point at the S. W. corner of the lot as appeared by the village plat on the easterly side of the street, the line passed directly through the S. E. corner of lot 124, taking no part of the lot, and thus making the reservation wholly within the tract conveyed; but by beginning at the river's edge, on the westerly side of the street, on the theory that plaintiff's property extended to the river, subject only to the easement of the street, the line would pass through and take part of lot 124. *Held*, that the former location of the corner was correct.—Anderson v. Scott, (Mich.) 42 N. W. 991.

33. Lands are not surveyed lands by the United States until a certified copy of the official plat of survey has been filed in the local land office.—United States v. Curtner, 38 F. I.

34. A county surveyor, employed to restore the lines and corners of adjoining tracts of land according to the original government survey, found township corners only, then (the other quarter and section corners being missing) ran a straight line from one township corner to the other, and on this line placed the quarter and section corners, but did not take any testimony to ascertain the lines or corners of the original survey, did not attempt to prove his lines or corners by re-establishing the missing corners from all the nearest known original corners, in all directions, did not sufficiently regard the field notes, and did not, where the original monuments had disappeared, regard the boundary lines long recognized and acquiesced in. *Held*, that such a survey is incomplete, and cannot be approved as the true and correct determination of the boundaries and corners as originally established by the Government.—Reinert v. Brunt, (Kan.) 21 P. 807.

35. Upon an issue as to the location of a line of the Government survey, evidence of the location of monuments is not overcome by field-notes of the original survey, taken at the time of the erection of said monuments or subsequent thereto.—Hubbard v. Dusy, (Cal.) 22 P. 214.

36. As between complicated descriptions of a line dividing two sections or quarter sections, that one is to be adopted which is most in conformity with the monument established by the Government survey.—Hubbard v. Dusy, (Cal.) 22 P. 214.

37. As between different monuments, those best identified should prevail, independent of anything in the field-notes of the original or any subsequent survey.—Hubbard v. Dusy, (Cal.) 22 P. 214.

38. Where it is doubtful which of two lines of monuments is the true Government line, other things being equal, that one is to be so considered which most nearly conforms to the field-notes.—Hubbard v. Dusy, (Cal.) 22 P. 214.

39. Testimony of declarations of a grantor, before the execution of a deed, tending to establish a boundary other than that made by the deed as construed by the court on appeal, is inadmissible; as its effect would be to convey land by parole in contravention of the statute of frauds.—Harris v. Oakley, 7. N. Y. S. 232.

THOMAS LOVE.

IT is with pain and regret that the secretary announces to the Society the death of one of its early members, Mr. Thomas Love. He was born near Hillsboro, Loudon County, Virginia, September 8, 1810. His parents were strict Quakers, or Friends, as they called themselves, and he was raised in that faith. In 1829 he attended the inauguration of Gen. Jackson, as President of the United States. He was in Ohio in 1830, and soon after came to Michigan and settled at Berrien Springs, where he was engaged in mercantile business for several years. He was Deputy County Treasurer of Berrien County from 1838 to 1840: in the latter year he was elected County Treasurer as a Whig, while the Democrats had a majority of one hundred on the general ticket. In 1844 he was elected County Clerk and held the office two terms. After this he went into the lumber business near Berrien. In 1854 he located at Avery, and, in company with another gentleman, built a saw mill which did a large business for many years, after which he engaged in farming and surveying. He was twice elected County Surveyor—in 1872 and 1874—and held various township offices. He was an efficient and popular officer, and was several times elected over adverse party majorities. He made a survey of the city of Niles and did his work so thoroughly that the surveys and monuments in that city are in the best condition of any city or village with which the writer is acquainted. He was agent for the Michigan Central Railroad at Avery for thirty years, and American Express Agent for twenty-five years or more. He was one of the founders of the Michigan Engineering Society, and always took a most active interest in it till the last. He did a large amount of work in the collection of material for the Manual of Land Surveying, and did everything in his power to advance the interests of the society. His dues were always paid in advance, and an extra dollar generally came with it. One of his last acts was to send the timber scribe to the writer for exhibition at the Detroit convention; he was then unable to sit up, and knew that he should never meet with us again. He died February 24, 1890, from old age, without disease or suffering. He was a gentleman of the old school, affable and courteous at all times. In the words of one nearest and dearest to him, "He was an honest, upright man, conscientious and truthful; what more can I say than that he was a gentleman in every sense of the word—one of nature's noblemen?"

F. HODGMAN.

THE ELEVENTH ANNUAL CONVENTION.

The eleventh annual convention of the Michigan Engineering Society was held at Detroit, January 21, 22 and 23, 1890. Owing to the general prevalence of *La Grippe*, a very considerable number of the members were absent who would otherwise have been in attendance. The earlier sessions were held in Philharmonic Hall, but on account of the light attendance it was concluded to hold the later sessions at the Plankinton hotel. A stenographer was employed to report the proceedings, but his report when received proved to be of very little value, and for this reason we are unable to publish any considerable part of the discussions. For the same reason Mr. Reed's description of work on the St. Clair tunnel is omitted. The business meeting of the convention was held on Thursday afternoon. The report of the secretary was read and accepted. The following is the report:—

SECRETARY'S REPORT.

I herewith submit the following report of business transacted for the Society since the last annual meeting. Everything up to the close of the convention at Lansing has been placed in the hands of every member of the Society in the columns of the Annual, and I do not deem it necessary to repeat it. In accordance with the orders of the Society, amendments to Article 3 of the Articles of Association were signed by the directors and filed in the office of the Secretary of State. The annual meeting of the Board of Directors was held at Hotel Downey, in the City of Lansing, October 9, 1889. There were present President Steele, Secretary Hodgman, Directors Cooley and Appleton. The meeting was called to order by the President and the ballots for officers canvassed. The following candidates, having received a majority of the ballots cast for the respective offices, were declared elected:—

President—R. C. CARPENTER.

Vice President—J. H. FORSTER.

Secretary and Treasurer—F. HODGMAN.

Directors—G. E. STEELE, M. E. COOLEY and C. E. GREENE.

The annual report of the Secretary was read and accepted. The directors examined the report and accounts of the Secretary and by M. E. Cooley reported that they found them correct.

The following is the report:—

SECRETARY'S REPORT FOR 1889.

I have to report the following business transacted by me for the Society since the last annual meeting:—

The first business after that meeting was to complete the program and make preparations for the annual convention. The list of papers selected at the annual meeting was provided for, as far as it was possible for the Secretary to do so. Circulars of invitation to civil engineers and surveyors throughout the State were prepared and sent to all whose addresses could be procured. A concession of special rates for the convention was secured from the Michigan Railway Association. The local arrangements for the convention were provided for by the Lansing members. It is not necessary to speak of the very successful convention which was held. At its close bids were solicited from various firms for the publication of the annual report. The job was let to the Review and Herald Printing Company of Battle Creek, on a basis of $240 for 1000 copies of 150 pp. each. Extra pages to be $1.25 per page, and cuts and extra work to be paid for by the Society. The report was out in May, and I took the liberty to christen it the Michigan Engineers Annual.

Letter ballots for new members and for officers were sent out early in the year, and the ballots for new members canvassed by me in time to include their names in the Annual. Certificates of Membership were made out and mailed to all new members the 1st of June. One copy of the Annual was mailed to each member of the Society not in arrears for dues, as soon as it was out. Copies were sent to others at subsequent times as fast as their dues were paid. Copies were also sent to all of our advertising patrons. Exchanges of reports have been effected with the Societies of Arkansas, Iowa, University of Michigan, and with the Provincial land surveyors and Dominion land surveyors of Canada. I have written the secretaries of the Missouri and Ohio Associations without getting any reply. The Indiana reports are late, but we expect them some time soon.

A good proportion of our income is derived from our advertising patronage, and without it our annual reports cannot be made what they have been. The Secretary has labored diligently both to secure such patronage, and to make the reports worthy of it, and I wish to especially acknowledge my obligations to Mr. Geo. L. Wells for the assistance he has rendered. If the members generally had been the tenth part as willing and helpful as Mr. Wells has been, we should have had the means of adding greatly to the value and attractiveness of our Annual. As agreed upon in the convention, the proceeds of a special contribution by the members was used to secure a portrait of Ex-President J. B. Davis. This was procured of the Eastman Dry Plate Company of Rochester, from a negative taken in Ann Arbor.

Some time a o a communication was received from a committee of the American Society of Civil Engineers, requesting the appointment by this Society of a committee to confer with them on the subject of preparing a plan of affiliation with the American Society, the committee to report to that Society by the 1st of November. I replied to the communication, notifying the writer of the time and place of our annual meeting, and requesting further information in regard to what the American Society desired. No reply has been received.

Notice of the annual meeting has been sent to each member of the Society, with a request for a response to it relative to place of meeting, subjects for discussion at the next convention, etc. I herewith submit such responses as I have received.

I also submit the following in regard to the finances of the Society:—

RECEIPTS.

On hand October 10, 1888	$ 111.85
Received from advertisers to October 9, 1889	234.95
Received from members for dues	221.00
Received from members for portrait fund	43 62
Received for Reports sold	7.25
From Wm. Appleton	50
	720.17

EXPENDITURES.

Paid balance on 1888 Reports	$ 92.04
Paid 1889 Reports and Portrait	359.57
Paid Stenographer	35.00
Paid Secretary's Salary 1888	50.00
Paid for Expenses on 1889 Reports	13.50
Paid for Stationery and Postage	48.44
Paid for Printing	27.08
Paid Expenses of Directors at Lansing	9.67
Paid for Express and Freight	12.30
Paid for American Digest	10.00
Paid for R. R. Certificates	1.00
Balance on hand October 9, 1889	61.57
	720.17

There is also due the Society from members for membership fees and dues and advertising $45.35.

No reports have been sent to members who are indebted to the Society, with the exception of new members who are only indebted for the senior membership fee. F. HODGMAN, *Secretary.*

The Secretary filed notices of sundry proposed amendments to the constitution and by laws. It was voted to hold the next convention at Detroit, beginning January 21, 1890, and the members in Detroit were appointed a local committee of arrangements.

The Secretary presented a list of topics furnished by members of the Society for discussion at the next convention, including papers promised by several members.

It was voted that the Secretary prepare the program for the convention.

The Board of Directors then adjourned. F. HODGMAN, *Secretary.*

Since the meeting of the Board of Directors I have endeavored to the best of my ability to carry out their wishes in preparing for this convention. In view of the repeated refusals of the Michigan Railway Association to grant reduced rates to Society meetings of various sorts, I did not deem it worth while to apply for special rates to this convention. I have made partial arrangements for printing the next number of the Annual, and have done something toward securing advertisements for it. Here I wish to repeat what has been said several times before, that it is very desirable that all the members of the Society who can, should co-operate with the Secretary, or publishing committee, in securing advertising patronage. Upon the amount of advertising secured, very largely depends the quality of the reports sent out as well as the number published. It was very much desired to publish in the last Annual a number of cuts illustrating the papers. It would add very much to the value and attractiveness of our Annual if we could with each number publish cuts illustrative of engineering work performed during the year by our members or others, and if we could have them from photographic negatives taken by ourselves so much the better. It is desirable to increase the circulation of our Annual by increasing

the number of our exchanges, thus increasing the value of the Society to each member by the additional amount of engineering literature furnished, and at the same time increasing the value of the Annual as an advertising medium. Something of this would have been done the past year if the finances of the Society had permitted, but it was thought better to keep entirely within our means, and incur no obligations that we were not sure of the means to meet. So we want each one of you to do what you can to secure advertising patronage; and not only that, we want you to help to keep that patronage by making it worth the while of these firms to advertise with us, by patronizing them in turn whenever we have the opportunity.

The late numbers of our report have been copyrighted. I think it would have been to the advantage of the Society if it had been done from the first. Authors all over the country have been using our work without giving us credit for it. If it is of value to them, they should pay us for it. In this connection I would suggest the question as to whether it might not prove profitable to the Society to classify the papers which have been published in the Reports and publish them in book form in several small volumes. F. HODGMAN.

Since writing the foregoing, I have received the proceedings of the Ohio Society of Engineers and Surveyors, and mailed them to all members of the Society not in arrears for dues. With them I sent the Dominion Land Surveyer's Report, which, by an oversight of my assistant was not included with the other reports when sent out. The Indiana report is the only one of our exchanges which has not been received. I learn that it has not been published but goes over to be published with the 1890 reports. After the past year's trial, I am inclined to think it is not the better way to send out reports by express at the members' expense unless they furnish the money to prepay charges. If this were done they could be sent to most of the members at a trifle less than by mail if sent in packages of four pounds or less. The postage is the second largest bill the society has to meet. It amounts to nearly $15. on the Dominion and Ohio reports just sent out. In connection with the photographic work of the Society it seems that it would be a good plan to have an exhibit at our next meeting of photographs by the members of the Society, and if we can also have a lot of lantern slides illustrating the work done by our members it would be a very valuable and attractive part of our program. Can we not have them?

The *Engineering News*, the *Railroad and Engineering Journal*, and the *American Engineer*, have been sent to the Society during the past year in exchange for our Reports. Every engineer should have one of these journals, and all of them, if he can afford it.

F. HODGMAN, *Sec'y*.

The following Amendments to the Constitution and By-Laws, which were submitted to the Board of Directors at their annual meeting, were submitted to the convention and adopted:—

AMENDMENTS TO CONSTITUTION.

ARTICLE II.

SECTION 1. The officers of this Society shall be senior members. Nominations for office shall be made at the annual convention. Election shall be by letter ballots, which shall be submitted to the Society previous to the next annual meeting of the Board of Directors. The ballots shall be canvassed and the result announced by the Board of Directors at their annual meeting. Officers of the Society shall hold their respective offices until the close of the annual meeting of the Board of Directors, and until their successors have notified the Secretary of their acceptance of the offices to which they have been elected.

ARTICLE IV.

Amendments to the Constitution shall be presented in writing at the annual convention, and submitted to the Society by letter ballot previous to the next annual meeting of the Board of Directors. The Ballot shall be canvassed, and the result ascertained and announced by the Board of Directors at their annual meeting.

AMENDMENTS TO BY-LAWS.

BY-LAW No. 3.—*Relative to applications for membership.*—The applications must be favorably indorsed by at least one member of the Society from personal knowledge, and be accompanied by a fee of $3.00. The application and fee shall be delivered to the Secretary, who shall refer the application to the Board of Directors for examination and approval. If approved by them, the Directors will determine to what class the applicant is eligible, and endorse their approval and classification on the application, which shall be submitted to the Society for action by letter ballot. Five adverse ballots shall reject a candidate. In case of the rejection of a candidate, the Secretary shall immediately return the fee to the applicant. If the candidate is elected, he shall sign the constitution, and if elected a senior member, shall pay the further sum of $2.00 as a membership fee. No additional fee shall be required from junior members. When a candidate is elected to membership, the Secretary shall give him notice to that effect, and upon receipt of the fee as above provided, shall issue to him a certificate of membership.

Letter ballots for members shall be issued to the Society by the Secretary on the first Monday in March of each year. The ballots shall be canvassed by the Secretary and the result announced to the candidates for membership on the first Monday in April of each year.

Candidates who have been elected to membership and fail to pay the membership fee within thirty days after being notified of their election, shall forfeit their membership and the application fee. The Board of Directors may extend the time for payment in any instance where satisfactory reasons are shown therefor.

BY-LAW No. 5.—Members desiring to withdraw from the Society shall make application in writing to the Secretary, paying all assessments and dues to the Society up to the time when the application is presented. The application shall be referred to the Board of Directors, who shall determine whether the application shall be granted or refused.

No member shall be liable to pay any dues or assessments levied after the time when his application for withdrawal is received by the Secretary until it is passed upon by the Board of Directors.

The following persons were nominated for officers for the next year:—

For President—R. C. CARPENTER, Lansing.
JOSEPH RIPLEY, Sault St. Marie.
J. B. DAVIS, Ann Arbor.
WALTER S. RUSSEL, Detroit.

For Vice-President—GEO. L. WELLS, Cadillac.
J. H. FORSTER, Williamston.
E. DENNIS, Jackson.

For Secretary and Treasurer—F. HODGMAN, Climax.

For Directors—GEO. L. WELLS, Cadillac, M. E. COOLEY, Ann Arbor, W. B. SEARS, East Saginaw. C. E. GREENE, Ann Arbor, GEO. E. STEELE, Traverse City, S. E. JARVIS, Lansing.

Applications for membership were received from the following persons and approved by the Board of Directors for Senior members: —

ADOLPH BARTHEL, Detroit, Mich.
G. S. WILLIAMS, " "
E. H. MUMFORD, " "
FRANK S. BIGLER, " "
MILO DAVIS, East Tawas, Mich.

The thanks of the Society were voted Mr. Walter S. Russel for the very acceptable manner in which he had provided for the local wants of the Society; to Mr. Clark, proprietor of the Plankinton Hotel, for many courtesies extended; to the Eastman Company of Rochester, for their exhibit of instruments, and to their representative, Mr. C. A. Stacey, for his demonstration of the manner of using the camera and making bromide prints. On motion of Mr. Forster, the sum of $50 was voted to the Secretary, in recognition of his services.

Mr. Livingstone read a paper, giving the results of tests of the engines of the steamer T. W. Palmer, during one of her regular trips.

Mr. Hyde exhibited some fine drawings and blue prints, and explained methods used in preparing them. The papers of Messrs. Livingston and Hyde were not furnished the Secretary for publication. The Society adjourned *sine die* on Thursday evening.

SUGGESTIONS OF THE SECRETARY.

1. When letter ballots are sent you, read the instructions and prepare your ballot in the manner directed, or you are liable to lose your vote, as many have done by their carelessness.

2. Have you done anything for the Society except to pay your fees and dues? If not, let us have a paper from you at the next convention. The active members of the Society are not doing their work for the $2 a year dues. They want the thoughts and experiences of others in exchange for their own.

3. Photographs are excellent for preserving records of engineering work. Let us have an exhibit at the next convention.

4. Lantern slides furnish the most satisfactory means of exhibiting views. They are not hard to make. Let us have an exhibit of views of our own make at the next convention.

5. What subjects would you like to have discussed at the next convention?

6. Notify us when you change your address. It may save your Reports from being lost.

7. The revenue from advertisements assists very materially in getting out a good Annual. One good turn deserves another. Patronize those who patronize us. They are all worthy of our patronage. Make it an object for them to continue their advertisements from year to year.

8. I have purchased the interest of Prof. Bellows in the Manual of Land Surveying, and am getting ready for another edition. What improvement can you suggest, to make it better?

9. Wanted, for the next edition of the Manual, the best and most practical solution of the following problem in surveying. Send us your solution right away.

The field notes of the line of a highway read as follows:—

Commencing at Meander Post No. 5, on the north bank of Kalamazoo River and running thence 1st *N.* 62° *E.* 14.00 chains; 2nd *N.* 43½° *E.* 8.00 chains; 3rd *N.* 5° *W.* 12.00 chains; 4th *N.* 72½° *E.* 10.25 chains; 5th *S.* 12° *W.* 6.43 chains to a stone set for Meander Post No. 3.

I commence at Meander Post No. 5, and with variation 2° 17′ *E.*, run a random line according to the field notes, setting temporary stakes at each angle in the line, and come out 62 links east of Meander Corner Stone No. 3.

1. What is the correction for the variation of the needle?

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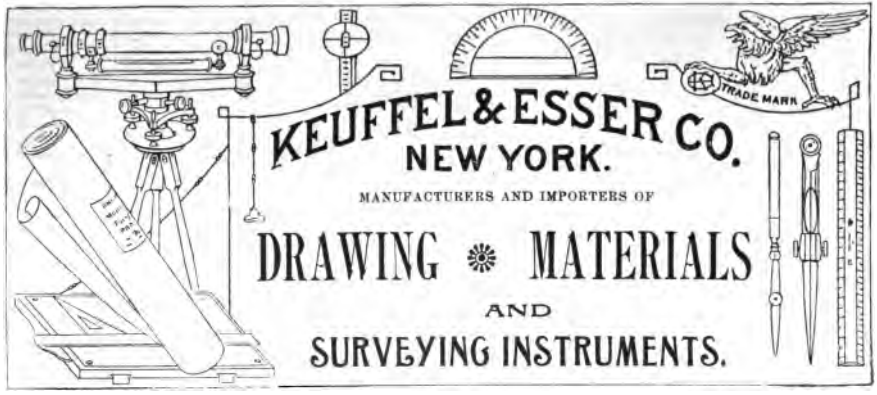

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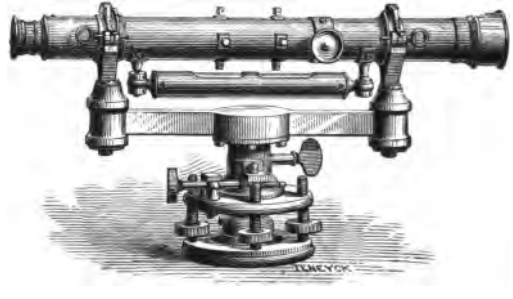

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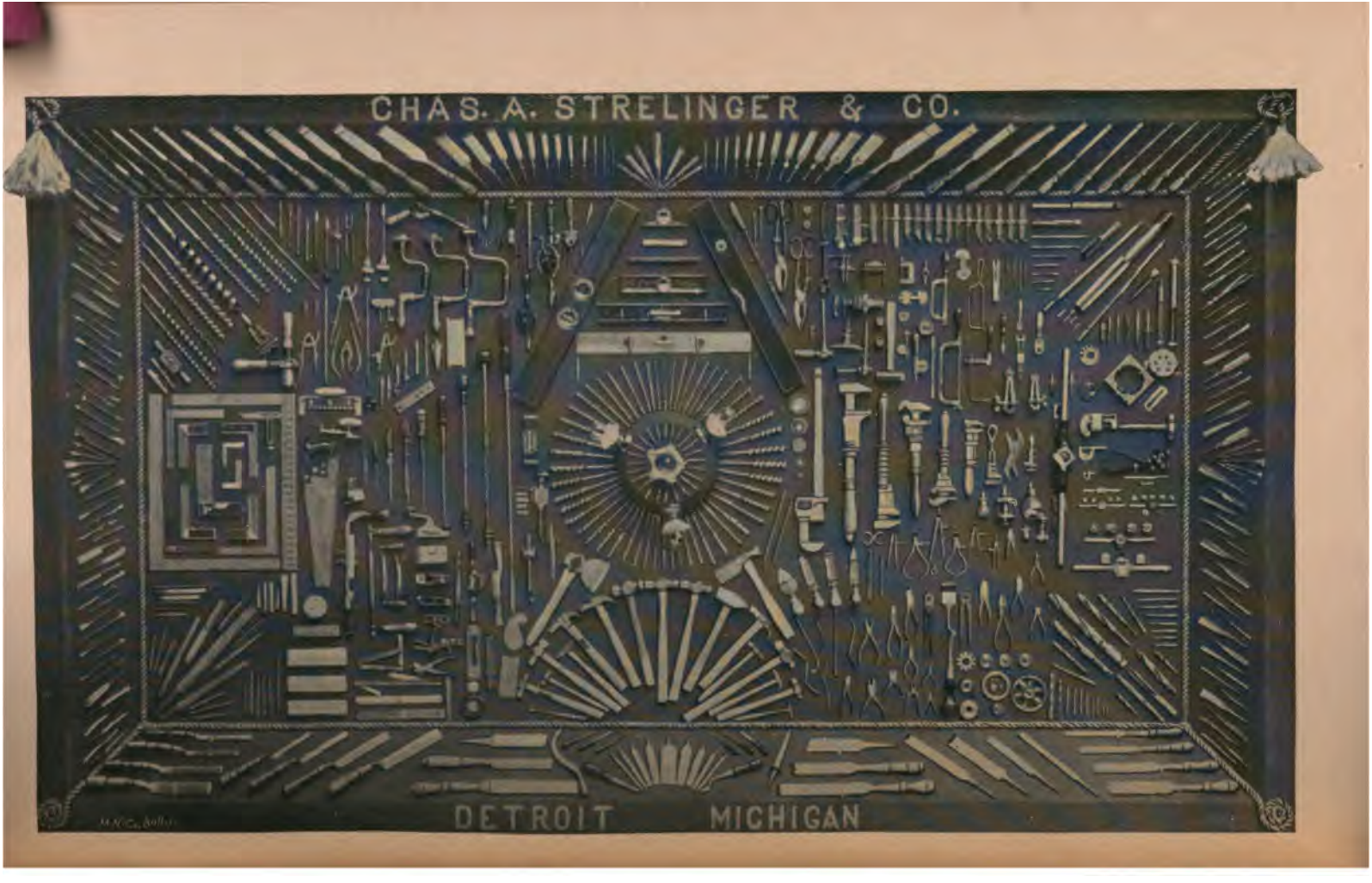
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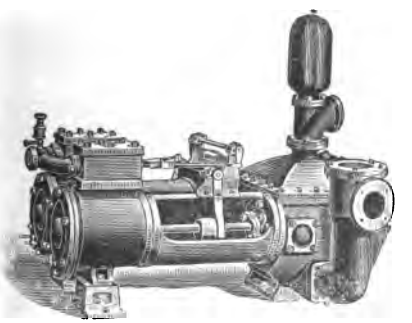

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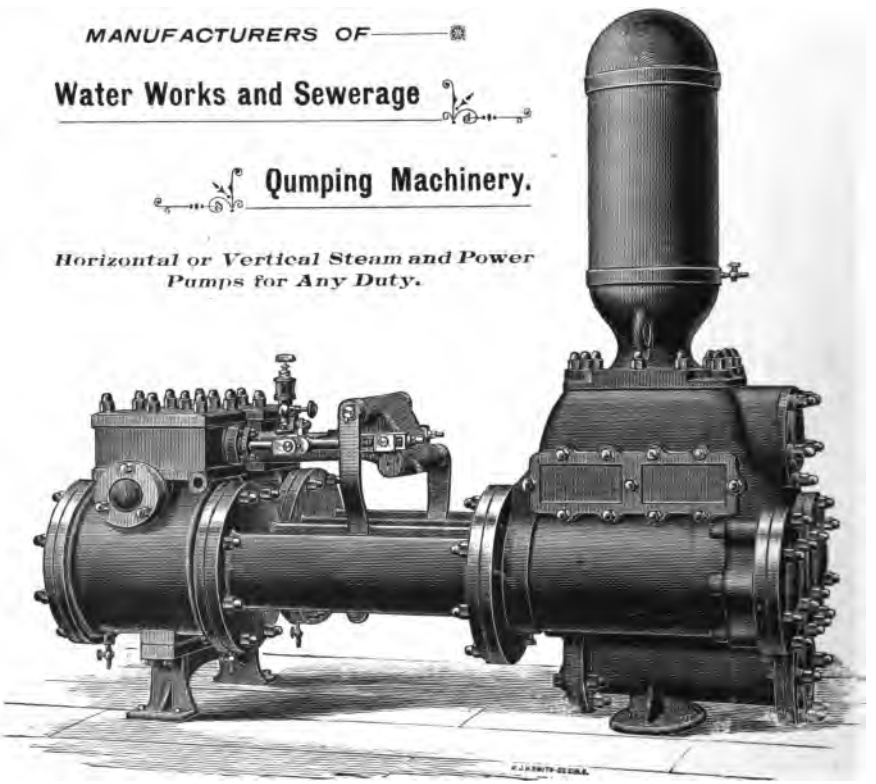

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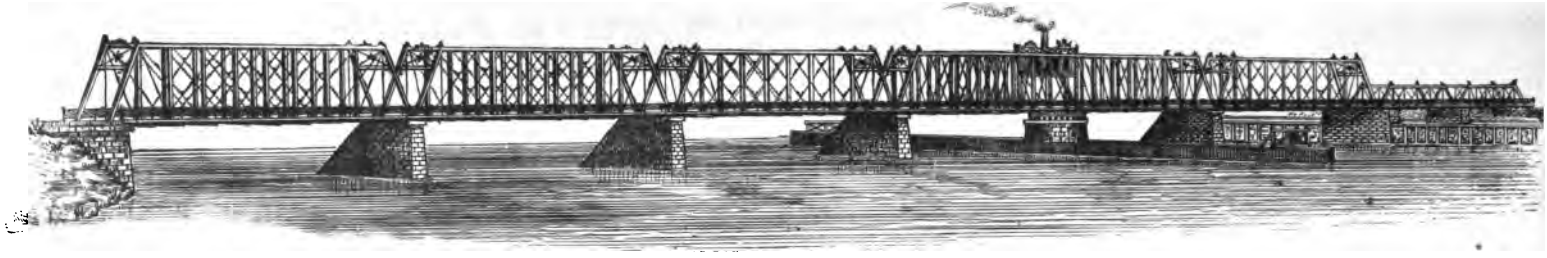

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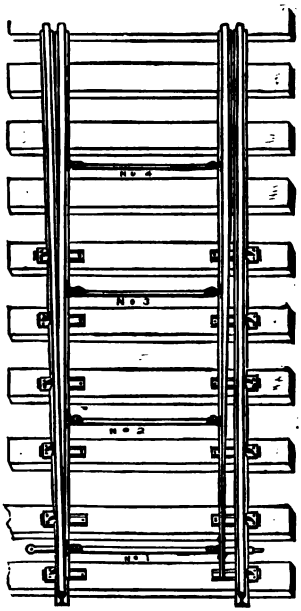

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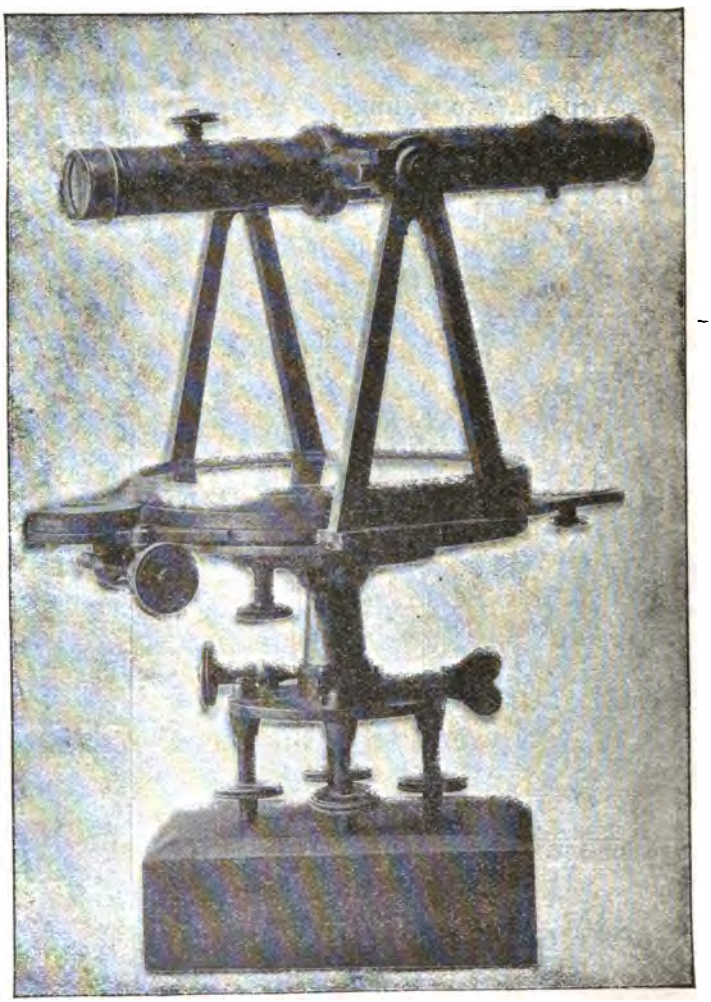

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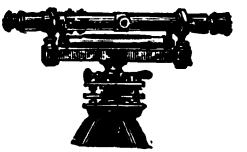

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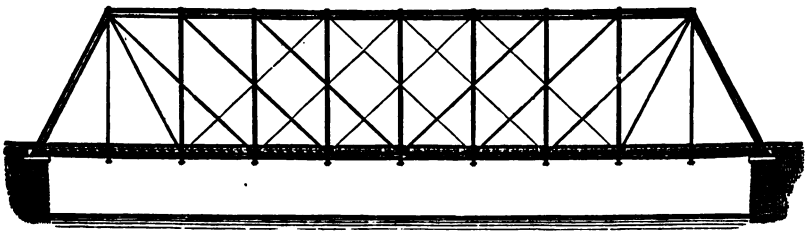

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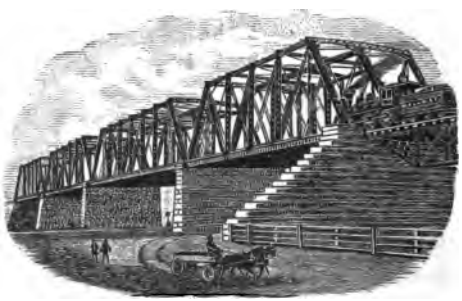

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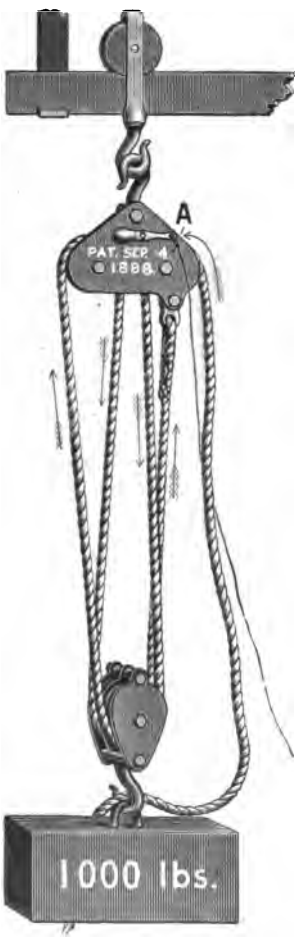

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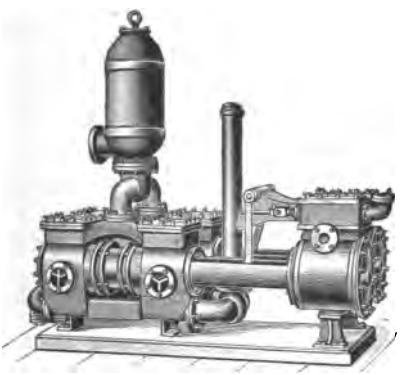

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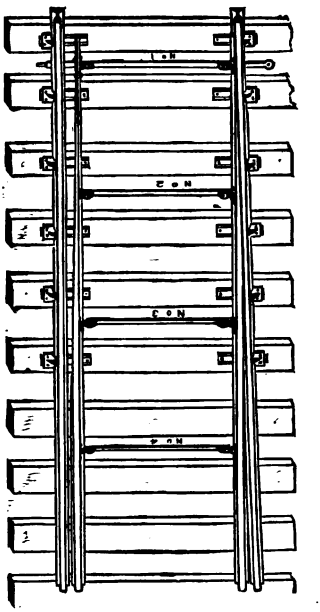

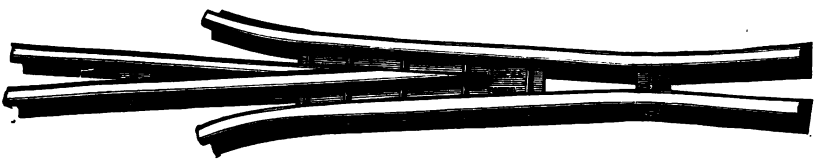

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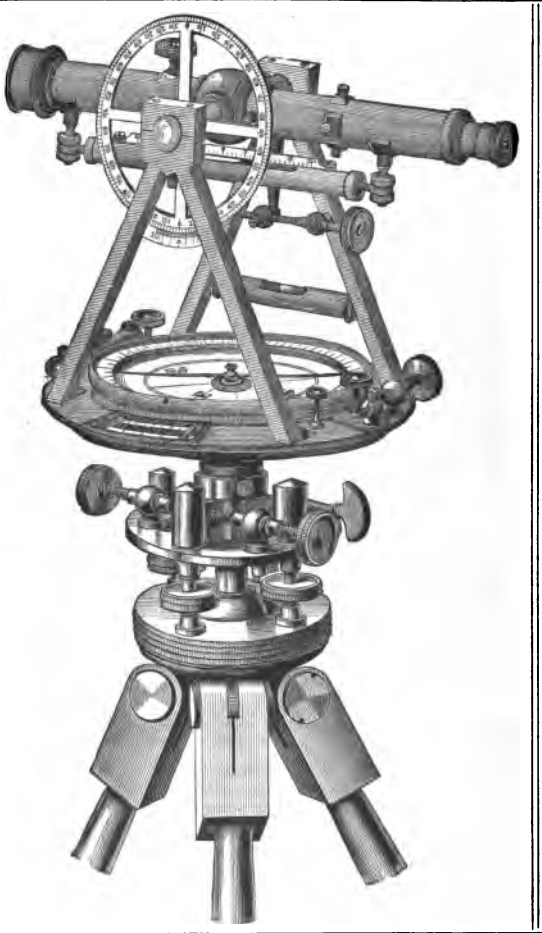

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PAPERS AND DISCUSSIONS

At the Twelfth Annual Convention of the Michigan Engineering Society, held at Lansing, Jan. 20–22, 1891.

THE EXPLORER AND HIS WORK IN THE COPPER REGIONS OF LAKE SUPERIOR.

THE existence of copper in the upper peninsula of Michigan, was known long before the researches of Dr. Houghton had brought the fact clearly before the public. Whereas float copper had been found in many places, it was reserved for our able State Geologist, just named, to demonstrate that native copper would be found *in place* and profitably mined.

The publication of his reports gave rise to a lively interest in the remote, little-known region, washed by the waves of Lake Superior, so that men lost no time in reaching those shores supposed to contain unlimited wealth.

It is not my purpose to write a history of that crusade, wonderful in many respects. It was the precursor of that greater crusade, which followed upon the discovery of gold in California. It was in reality the beginning of that intense activity, mental and material, which has characterized the last fifty years of our national development, beginning at the close of the Mexican War.

But my aim is, in this paper, to show how old-time, practical copper hunters did their work. A surveyor who undertakes to survey a country, likes to reach a commanding point, whence he may view the whole field, and fix in his mind a general idea of its outlines and topography.

In imitation of this discreet person, the writer must pause a moment to give you a brief description of the copper region, as traversed by our explorer.

DESCRIPTION.

The copper-bearing rocks on the main-land in the Upper Peninsula, lie in a narrow belt averaging from three to four miles in width, and 150 miles in length, starting from the northeastern extremity of Keweenaw Point, and ending near the Wisconsin line on the west.

Isle Royale, on the north side of the lake, is also a copper-producing section.

The country, when discovered by the white man, was clothed with a luxuriant forest, the prevailing timber being pine, maple, birch, hemlock, fir, and cedar. The underbrush was almost as dense as a jungle. The surface of the country on the trap ranges, is, generally speaking, rough and broken; knobs and ridges have an elevation of from 400 to 1,300 feet above the lake. The streams are short and swift, and small lakes frequently occur. There is much level land, and extensive cedar swamps. Most of the country is covered with a deep drift of bowlders, sand, and gravel, with some clay.

Many of the rocky ridges are very picturesque, presenting ragged escarpments on their southern faces, and sloping off gently to the north. This feature arises from the fact that the whole trap range has been elevated from its horizontal position, and tilted up, the south side of the range being the higher and bolder, the descent or inclination of the beds being in the direction of Lake Superior, which is an immense trough, the rocks or beds of the same character on Isle Royale dipping to *the south* toward the center of the lake, just the reverse of those on the south shore or main-land.

The line of cliffs in Keweenaw county, at the point where the once famous Cliff mine was developed, offer a good example. This bold range rises out of the main range, and is several miles long. When viewed from the south, it gives one an idea of an artificial battlement, constructed by giants, of course; its perpendicular walls, more than 100 feet high, swelling out and retreating, yet conforming to one general plan line. The rocks are what is known as greenstone, a fine-grained, crystalline rock. The face of the

cliffs presents a good example of the step-like formation of trap; it looks as though composed of huge square blocks of stone solidly set, but not brought to a regular even face. One may climb up these steps with more or less ease, but the attempt would not be particularly inviting. The weathering for ages has added much to the picturesque in the cliffs.

The cliffs appear lower than they are, on account of the immense accumulation of débris at their base, thrown down by water and frost. They are crossed by heavy fissures, having a northerly and southerly trend. These fissures are now filled with mineral matter deposited by mysterious currents, probably electrical.

The great Cliff mine was based upon one of these fissure veins. The copper, produced in such quantities as to enrich the proprietors, was what is known as mass copper. It was found in the vein imbedded in calcareous matter, in great lenticular masses, often hundreds of tons in weight. It was cut under ground, with large chisels, in pieces convenient for hauling — say from four to eight tons each. The matrix, or vein stone, so called, was beautiful spar, taking many crystalline forms, and sparkling in the candle light like the gems in Alladin's Cave. Much native silver, white and lustrous, was found associated with the other minerals.

Greenstone cliffs are common in Keweenaw county. Ridges of similar character but not of the same mineral structure, are found in Ontonagon county. None occur in Houghton county, the surface of that county showing but little denuded rock in elevation.

For this reason, this county, though now the greatest copper producing district in the world, was kept in the background. The deep drift overlying the rocks hid the veins and lodes from the casual explorer. The field was not inviting, and so Keweenaw and Ontonagon counties, being more favorably conditioned, received the attention of the first settlers, and took the lead in mining.

It required thorough examination and digging to find many of the lodes in Houghton county, but they were known to be there somewhere. Tell-tale floats found in the woods — vein-rock containing copper — hinted at mother beds beneath the soil. In the hills, flanking Portage Lake, veins were first found and opened.

Rich pieces of broken vein-stone — conglomerate and amygdaloid — found in the leaves in the woods, led to the discovery of the Calumet mine. But the belt or conglomerate lode was found only after digging 25 feet through sand and gravel. And in

this very pit remains of ancient explorers were found — birch-bark baskets, stone hammers, copper tools, and charcoal. But more of this farther on.

The Calumet and Hecla is founded upon a belt of conglomerate running *with* the formation, hence is wholly unlike the cliff fissure, before mentioned. The copper is also in a different shape. I beg to say, once for all, that all Lake Superior copper mined, is native or virgin copper, not an ore. At the Calumet it is what is technically called stamp copper, that is, the metal occurs in the gangue in flakes and shot-like forms throughout the whole lode, and is extracted by means of stamping and working. This in the richer deposits; in the poorer parts of the lode are barren places. There are no mass veins in Houghton district. The Franklin and Quincy mines and others not working, are based upon amygdaloidal belts, running with the formation, about N. 32 East, of enormous width — say from 20 to 50 feet — while the Calumet is, say, 15 feet, and the cliff fissure, three feet. Besides rich stamp work, these mines raise much small mass work, running up into tons. These belts contain a great variety of beautiful minerals for the cabinet.

The Huron and other mines, on the south side of Portage Lake, are found in what is termed epidote-quartz vein-matter, instead of calcareous rocks. Much small mass copper is found here also, but the chief dependence of the miner is on stamp copper.

The Atlantic mine on the same side of the lake, on the Quincy group of rocks, is still different in character. The vein-stone is a chocolate-colored, soft rock, with shot-copper lying all through the mass, with very little heavy metal.

In Ontonagon county have been found many stamp lodes with epidote and quartz, as the characteristic vein matter.

But the well-known Minesota lode was of a different character from any heretofore enumerated. It was a mass lode, but not a fissure vein, like the cliff. Its course was *with* the formation, like the Calumet and Quincy lodes, and, like the Calumet, the copper was associated with conglomerate, but it is a *contact* lode: that is to say, the enormous masses of copper found in it, reposed between the conglomerate bed and the trap of the country. This, in general terms; for really the copper was often found extending into the inclosing rocks

GEOLOGY.

The geology of the country, by taking a cross-section in Houghton county, is as follows: We find the low-lying country flanking the trap range quite level, underlaid by old red sandstone, in which are found valuable quarries. The timber is pine, fir, birch, and hemlock mainly, with cedar and tamarack swamps. At the junction of the trap and sandstone, the range presents a bold, steep front, cut by deep ravines, showing some beautiful water-falls and cascades. On the immediate shore of Lake Superior, fronting magnificent Keweenaw Bay, occur long lines of perpendicular, wave-worn, brown sandstone cliffs. Traversing the trap range from south to north, we find numerous belts of trap, varying in hardness and structure. But within these belts, and in conformity, but not blending, are found many strong conglomerate belts from 10 to 50 feet wide — the wreckage of pre-existing formations — wave-washed, smooth, rounded bowlders, cemented into a solid mass. This is a very curious feature, and a study, giving rise to many pressing thoughts as to the age of the trap rocks, the manner of formation or deposition, as well as the character of the prodigious forces which uplifted the range and changed the structure of some of the rocks. On the north side of the range we find flanking it, metamorphic sandstone, hard and with a metallic ring under the hammer. Did fire change this rock? Are the trappean rocks belts or beds of sedimentary origin? How did those numerous conglomerate belts find their place at different lines throughout the three-mile-wide mass of trappean rocks? But this is no place for a discussion of these interesting questions.

Concluding his general description and having reached the vantage point sought for, the writer will now proceed to show, as well as he can, how the old explorers went to work to find mineral veins and deposits of copper, thus opening the way to mining.

Our explorer, in the first place, must possess some such fitness as was displayed by Cooper's path-finder. He must be a good woodsman, hardy, self-reliant, brave, and sharp-eyed. He must be strong enough to carry a pack on his back, filled with his blankets, provisions, frying-pan, tin cup, and camp kettle. His dress must be strong and warm, embracing a slouch felt hat, a heavy flannel shirt, a pair of strong pantaloons, re-inforced by bed-ticking, sus-

tained by a heavy belt, from which depend hunting knife, exploring pick, and pistol; with feet encased in shoe-packs or moccasins well stuffed with woollen cloths. In his pockets he carries a compass, some fish-hooks and lines, his pipe and plug tobacco, and a match box carefully secured. No good explorer will carry a pocket-pistol, or liquor with which to muddle his brain and sap his strength. A cup of strong tea is the best stimulant he can find, as he sits by his camp fire after a hard tramp.

The very first preliminary explorations were conducted by parties composed of six or eight persons, and Mackinaw boats, yawl boats with sails and canvas, were used in coasting. The chief business of the party was to hunt up mineral tracts, and secure them by "permits" from the government. A land surveyor and a geologist accompanied the party.

Explorers soon found out that the magnetic needle was untrustworthy on the trap ranges, where iron and copper disturbed it, and electric currents are strong. No accurate surveys could be made with a common compass.

The ingenious and ingenuous chief of our party, however, was equal to the occasion. His scientific attainments were greater than his knowledge of practical surveying. He suggested to the writer that the magnetic disturbance did not extend far above the surface of the earth, and if he would climb to the top of the highest trees and set his compass there, he could get the course of any given line by sighting forward to the next farthest tree he could see, then come down and proceed to find that tree by some occult way, climb it—and "go ahead." The writer admitted the novelty of the suggestion, and its scientific *ass-pects*, but hinted in return that a gorilla, who was a good climber, be secured as surveyor.

Geologists were in great demand: were considered indispensable. But it soon transpired that some of these gentlemen, if not charlatans, were mere book-men, with no knowledge of woodscraft, and with only such knowledge of minerals as an amateur could obtain in a museum. The "deep-tangled wild wood" was a terror to our geologist, and he could not be induced to quit the lake shore. So he abided in camp, and sent the surveyor and his other young men into the woods to explore and fetch back to him bags full of minerals for him to examine and analyze. As these young men were as ignorant of minerals or veins as sucking doves, much worthless trash was lugged in with infinite toil. For ex-

ample, the common quartz rock and iron pyrites were brought in as specimens of gold veins!

But such was the *modus operandi* of our distinguished geologist. Could any good thing come out of him? "Not much!" One expedition was a failure — nothing more. But there were compensations. The geologist was dropped out of our party, and our young men soon became skilled woodsmen — good practical mineralogists, and no mean adepts in geology. They at least knew copper-bearing rocks when they saw them, and could distinguish copper from other minerals.

Professionals ere long dropped out of the line, and practical explorers took the lead.

Do not understand that I say there were no good geologists in the country. There were many, such as Hubbard, Douglass, Jackson, Foster, and Whitney, Col. Whittlesy, and others.

In the exploring party there were several packers and axmen, who acted as boatmen on the water. They were remnants of the old fur-trading companies — Canadians, French, half-breeds, and Indians. In service they were first-rate men, used to the water and the woods, hardy, patient, cheerful, and enduring. But when they had access to whisky in the camp, they forthwith got drunk, and quarreled like wild beasts. After they became insensible, through debauchery or fight, our officers dragged them to the boat and threw them in, hoisted sail, and made for some distant stream or bay, and encamped for the night. When the men had sobered off, they resumed work with their former ready obedience.

These parties made long coasting voyages, often indeed, circumnavigating the great lake. But they made frequent stops, running into the mouths of small streams which afforded shelter. The boat was hauled out and covered with hemlock or spruce boughs. Thus she formed a store-house for surplus provisions. The packers were loaded with provisions and cooking outfit, and the whole party set out for the interior to explore the copper range. Days and weeks elapsed before the party returned to the boat. Meantime, they were supplied with provisions from the boat by the packers who were kept on the trail. They finally returned to the shore, and resumed their voyage to the next place on the program, and so on, to the end of the season. These lake voyages were generally pleasant and interesting, but often dangerous in stormy weather, causing much loss by drowning. But this somewhat

cumbrous and inefficient mode of exploring soon had its end. One result was derived from it: a general knowledge of the whole country was obtained, which aided subsequent researches.

We come now to individual enterprizes. Our practical explorer, inured to hardships and at home in the woods, took to the bush alone, or accompanied by one packer, who acted as cook and man Friday.

Some central, quiet nook in the heart of the mineral region to be examined, was selected for a camp, always by the side of a running stream. Here in the solitary, trackless forest a wigwam was made of poles covered with cedar or birch bark, or with evergreen boughs. The hut was just big enough for two, with no guest chamber. A fire blazed in front night and day, for warmth, for cooking, and for protection against prowling wild animals, such as the gentle porcupine, the lynx, and the black bear. The little streams were all teeming with small brook trout which, caught with our pin hooks, garnished the morning and evening meal of hard-tack, pork, and tea. A porcupine stew was had on select occasions. The woods were full of partridges, almost as tame as barnyard fowls. These, when dressed, we cooked on sticks stuck in the ground and inclined toward the fire.

Our evenings, after a hard day's scramble through the woods, were happily spent reclining on our beds or carpet of sweet smelling pine or spruce, smoking pipes and exchanging song or story. When quite alone, as was often the case, when his man Friday was away after provisions, the solitary explorer found his evenings rather lonely. The quiet, the hush, the profound stillness of the deep, dark forest were somewhat awful. The imagination was quickened, and the fancy began to cut up terrible capers. The fall of a twig was almost a catastrophe, and the breaking of a branch out there in the darkness, was almost an earthquake, while the unexpected and unearthly yell, like the wail of a lost spirit, of a prowling lynx, would curdle the blood in one's veins and make every individual hair on one's head, stand on end. At times, when in certain moods, the impressive silence of the solemn woods was too awful, and the oppressed soul must needs find relief in sobs!

The writer, however, spent many a happy and joyous day in the woods alone, in exploration. From May until August the mosquitoes and black flies interfered much with hisw ork, but after

they had lived out their blood-thirsty days, a season of peace and high enjoyment followed. Especially in the mellow October days, after the early frosts had burnished the forest panoply with a brush dipped in the rainbow, our delight was such as not to be forgotten now after the lapse of more than forty years.

Mounting some lofty knob, bare and bald as the writer's head, our explorer would throw himself upon the smooth, rain-washed rock, swept by the winds of a thousand years, — yea, of thousands upon thousands, with no account of the years it was buried under the old glacier a mile in thickness, — light his pipe, and dream. He sees over there in the south, stretching away to the horizon, mile upon mile, a forest of green and gold and purple and yellow and scarlet, a solid mass of foliage basking in the soft sunshine. This variegated carpet from Nature's great artistic loom, soft and pleasant to the eye as a Wilton, is only broken here and there by some protruding knob, or intervale through which winds, with many turns, a silver stream, now lashed into foam by envious rapids, now leaping over a precipice, but still seeking its way persistently to an outlet where it may hide itself in the bosom of the great lake.

Reversing his outlook, he beheld far off, and far below, the broad blue expanse of Lake Superior, the mother of lakes and streams gigantic, sleeping quietly, and gaining strength in repose, for the battle to come with winter elements. Not a ship or speck dots the silver expanse, and solitude seems to reign on the water as well as on land. Nature, without man and his busy ways and inventions, seems as lonely and incomplete as was the first man in the garden of Eden.

Now the summer fly, benumbed by last night's frost, drones lazily in the air; a soft breeze stirs the leaves; the pipe drops from our explorer's mouth, unheard upon the rock; sleep wraps all his senses in oblivion. But a short clap of thunder awakes him; the sky is overcast, and great rolling, swaying thunder-heads, bellowing in their anger, and shooting out zig-zag flames, are seen in the south-west, unmistakable warnings that he must speedily seek his camp for shelter. A rapid tramp down the steeps and through the woods brings him home none too soon. The rolling and crashing of thunder above the tree tops is appalling. The woods are pitchy dark; the trunks of the trees, revealed by the glaring lightning, look like spectres. The wind howls, and the aged tenants of the

forest go crashing down. Broken limbs fall to the ground dangerously near. At first, in the wild hubbub of nature, no rain seems to fall. The dense foliage arrests it; but too soon it comes pattering down, at first gently, then in floods. The rude wigwam is no defense against such a down-pour, and our explorer, without fire, without light, sits disconsolate, wrapped in his drenched blankets, wet to the skin. The storm soon passes, and the thunder is heard far off over Lake Superior. But our explorer cannot kindle a fire with wet sticks, so he wraps himself tighter in his wet blankets and says, philosophically, to himself, "I am in for the night."

Occasionally our surveyor in the midst of his labors is caught out in a snow storm. His miseries entailed by wading in the snow, handling rocks in the snow, building a fire in the snow, and sleeping in the snow, are such that he likes not to dwell upon them. He prefers always not to harbor the unpleasant things of this life in his bosom, but to let them "*slide.*"

Our explorer is reminded by his conscience just here, that it might be the wish of his hearers that he would attend a little closer to the business in hand. Bowing to the admonition, he will now show you his way of exploring.

The first aim of the explorer was to make preliminary examinations of the particular tracts. If the section lines had been marked, his work was easier. He had only to find a corner, and assume one of the lines as his base. Pacing south, say twenty rods, he would stop to hack a tree, then start due east by compass, pacing the distance as he advanced. The writer's practice was to take short easy steps of two feet, and as he went on, keep count in his mind of every step. This mental effort soon became automatic, not hindering the use of eyes or hands. A note-book was carried, in which the topography was sketched, with full notes of every ridge, depression, outcrop, or stream, as well as the character of the rocks seen. When any outcrop demanded more than a passing examination, a pause was made, a tree in line notched with the pick, and distance from starting point noted down; a divergence was then made right and left, and a careful examination of the rocks for valuable minerals was made. Returning to the hacked tree, our explorer resumed his east and west line, keeping his eyes open to anything of importance. The mental tally for a mile having closed, he would look out for the section line. After long practice, he rarely failed to find the line at once. The next step

was pacing down the line twenty rods, then going west in the same manner as before, repeating the operation until the whole section was thoroughly gone over.

Such full notes were obtained that when he reached camp, or the office, he could plot them, and obtain a topographical sketch, including the geology and mineralogy of the section. Should any vein or lode have been discovered, its position was fixed so as to be readily found at some future time.

A more general survey was made by starting from known points in a township; and by compass line and pacing, and checking upon corners, a reconnaissance was made of prominent ranges and outcrops. Where the country was not subdivided, connection by compass and chain, with some prominent point on the lake shore, as a bay, mouth of river, etc., had to be made.

After much practice, our explorer became quite expert, not only in woods-craft, but in finding valuable mineral deposits. He acquired much of the skill possessed by an Indian in following traces and indications. The deep drift and soil overlying the rocks in places, called for the exercise of much patience and ingenuity. He must know the character of any rock found on the surface, and whether it was likely that it belonged to the hidden beds; or whether as a traveled bowlder it had come from a distance. If a bowlder, he must understand how it came there, as, also, the direction it had come from. Observation as to glacial scoremarks on denuded surfaces, give the general course of the ice currents. If the interesting bowlder, or "float," has been torn from copper-bearing rocks, like amygdaloid trap or conglomerate *in place*, he decides that it is a vein rock. Should some speck of metal be found, after chipping or breaking the "float" with the exploring hammer, the interest is greatly increased. The next question to be solved is, How far has this bowlder traveled? If it is hard, smooth, and rounded, the conclusion is that it has come from a distance, no one knows how far. But if the rock breaks easily under the hammer, is angular, and little worn, then the conclusion is that the mother vein or lode is not far away. The explorer now pulls out his compass, and ascertains which way northeast is from his position. He follows this course slowly, like a hound, turning over with his pick, and critically examining every stone in his path. As he proceeds, the number of stones multiply, vein-matter is more abundant, and is richer in copper. Finally a little further on, the whole

surface of the ground is covered with vein débris. Still, passing beyond this point, to his surprise he comes to smooth ground, with no stones to be seen. He now goes back to the point where bowlders were strewn the thickest, and says, The lode must be somewhere near here; for the fact that I found no bowlders farther east, is conclusive evidence that it is not *there.*

Where to sink a test pit now exercises his best judgment, and the question requires much thought. He wishes to strike the lode as soon as possible, without unnecessary digging; for exploring with pick and shovel is slow, costly work. Finally he assumes a point south of the supposed position of the vein to be discovered, and orders his men to sink there. After he gets down a few feet, he finds that the mass of bowlders lie on an incline plane; that the vertical depth of the débris is greater right near the vein, and that, as you recede from it, southwest, the débris grows shallower, until it runs out, the moving force, the glacier, having pushed that way, dropping its wreckage in the order named. Hence several trial pits have to be made before you begin regular trenching. If you find the débris, or bed of drift vein-matter thin, you judge you are too far from the mother lode, too far south; and you move up north, and sink again.

The difficulties encountered in this kind of work are very great, involving much time and expense, especially if the soil is deep and the water quick. The aid of steam pumps is often necessary. The final results are often disappointing, entailing great loss; but should you happen to find a rich lode, the joy and elation caused by the event are indescribable. It is no less a thing than the discovery of great wealth to enrich and benefit a nation.

The intelligent explorer, aside from the glory which attends his successful efforts, finds not only, as Shakspeare says, "sermons in stones," but much that interests him generally, in nature's wondrous ways. His attention is arrested by the varying structure and quality of the underlying rocks, which form the back-bone of Keweenaw Peninsula. The deposition of various minerals, in veins or lodes, by electrical currents, affords evidence of a powerful agent working silently and unseen. Some other powerful agent has disturbed the whole formation in a powerful way, rending it asunder, and tilting it up.

Then his superficial explorations afford more food for thought. The drift and soil covered with old forests has many utter-

ances of the past. It claims parentage of the glacier — cold, hard, crushing, grinding parent indeed, yet still not without beneficence.

The pulverized rock, ground to silt, clay, sand, and gravel, is spread over the barren, stony plains, inviting the growth of moss, shrub, plant, and in time the mighty pine, with its graceful bird's-eye maple associate. But while this deposition is taking place, the bedded rocks of the country are not only rasped off and smoothed by the ice planer, which is shod with feet and points of hard green-stone and granite, scoring and grooving the softer amygdaloids imperceptibly, but leave indelible traces of their work for our instruction and guidance. For the score marks often lead to practical results; they are the keys, so to speak, which unlock hidden treasures.

Many examples might be given to illustrate the line of movement and force of glaciers. The writer will offer one. Ranging the woods and becoming tired, our explorer sat down upon a moss-grown bowlder, took out his restful pipe, and began to smoke. Casually he tapped the bowlder with his pick. The metallic ring it gave out startled him. He speedily tore off the accumulated moss of ages, and, lo! a great mass of solid copper met his astonished gaze. This mass, when finally cut up, weighed eighteen tons, and was worth $10,000. It was smooth on all sides but one; that side was serrated, as though the mass had been torn violently from its matrix and with great force, for the mass was two feet in thickness. Will any one venture to calculate the tremendous power that broke in two this tenacious lump of copper? Examination showed the fact that the outlines of the mass, smooth and hammered, had not been shaped by the glacier, hence it was decided that this interesting and gigantic "float" had not traveled far, and that the vein it was torn from was not distant. The smooth appearance of the copper bowlder was attributed to the work of the "ancient miner." And, just here, you are introduced to a very old explorer, — no one knows how old, — but one of the most useful and skillful men that the modern explorer has any knowledge of; one he is glad to associate with fraternally, but only through his works.

Now the discovery of this great mass of copper doubtless caused our "ancient miner," or explorer, to leap with joy, as it did us. But his extreme elation did not last. He soon found out, to use

a modern phrase, that he had an elephant on his hands. The treasure was too large and solid. But he did the best he knew how with his stone and copper tools, knocking off all projections. In vain he tried fire to soften and reduce the mass. He doubtless secured many small pieces, but was obliged, finally, to leave the major part of the copper. We can fancy that he felt blue as he took up his line of march to his canoes, leaving so much wealth behind. Human nature is ever the same. But he left numerous stone hammers, copper chisels, and much charcoal about the mass, to attest his work.

Leaving the big mass for a while where it was found, to be gazed at by thronging visitors, the explorer went about to find whence it came. It lay upon a rocky ridge where the glacier dropped it. Our explorer set his men to work trenching some 50 feet to the north and east of the mass. Within a few days the mother vein was found, and so truly, that after uncovering it, the very spot where the mass had been torn from, was struck. Sticking up in the vein, a mass of copper was exposed with upper edges rough and jagged. By actual measurements, it was found that the "float" mass would just fit to the one in place.

A mine was opened on this vein, but like many another, it disappointed expectations. The copper, *in place*, was blown out by a "sand blast," and *that* seemed to be all there was of it. The mine was a failure.

The float mass was cut into pieces convenient for handling. A steel chisel with a long shank was used. Two men, with heavy steel hammers, struck the chisel. The groove cut was about one inch wide. The process of cutting was slow and laborious.

One word about these "ancient miners," so called for want of a better name. Everywhere throughout the copper districts, including Isle Royale, on the north shore of Lake Superior, they have left numerous evidences of gigantic operations, as well as of much skill. Their stone hammers, also other rude implements, are found wherever there are copper veins. So far as the writer knows, no great successful mine has ever been opened in the Lake Superior region, that did not show on the surface, the work of the unknown man. Many striking examples might be adduced, but the limits of this paper forbid. Their sagacity in finding lodes, or veins, is what astonishes the modern explorer more than anything else in these wonderful people. There may or may not have been heavy

forests covering the copper ranges at the period or periods of their visits, but it is certain that the same drift matter that now overlies the bed-rock existed in his day; for all his work, shallow or deep, is found in the drift sometimes to the depth of 50 feet or more. But he had no steel tools or powder; his work was performed with wooden shovels, birch-bark baskets, stone hammers, and rude copper chisels. Fire and water were his agents also. He likewise used wooden wedges and wooden levers, or pries.

These remains found in ancient pits, covered with leaves and sand and large growing trees, prove that there was timber growing in the district in his day, but to what extent we cannot tell.

Perhaps it is idle to speculate as to what race these prehistoric people belonged. The aborigines of the country knew nothing about mining for copper, or its use. Indeed, they were very superstitious in regard to copper, and always refused to reveal any veins that they professed to know of.

But these prehistoric races may have been of the same kin as the Chippeway. They may have resided in a milder climate, on the borders of the Ohio and Mississippi, and been a pastoral people. Who knows? Stanley finds in Africa cave dwellers, tree dwellers, and lake or river dwellers. He finds men of the stone age, bronze age, and iron age, all living in the same period and country.

Down in New Mexico and Arizona, we find to-day savage Apaches, without home or dwelling place; we find mound builders in pueblos, cave dwellers, pastoral people with flocks and herds, wheat and cotton growers, spinners and weavers of cotton and wool, all essentially alike, all Indians.

But we are wandering from our subject.

Our copper explorer, after he has found a workable vein, turns it over to the regular miner, and his work may be said to be done. But he seeks new fields. Notwithstanding so much has been done, more remains to be done. Such is the extent of the copper districts, and so great are the difficulties to be overcome in explorations, that it may truthfully be said that very little is yet known of the vein phenomena of the lake region. All that has been done, important as it is, might be termed mere scratching of the surface. It remains for the future to unfold other hidden treasures of that great and wealthy section of our State. Generations hence there will be new "finds," new disclosures. As the present working

mines become impoverished, or should a greater demand for that useful metal, copper, spring up, explorers will be stimulated to new exertions, almost sure to be crowned with success.

Accident often plays an important part in discovery. At any time some wood-chopper or partridge hunter may stumble over a mass of copper in the woods, and a great lode be revealed that will enrich the world.

The possibilities of the Lake Superior country are not within calculation. JOHN H. FORSTER.

EASEMENT CURVES.

A RAILROAD track, as usually located, consists of a succession of tangents and circular curves. When a train, moving rapidly along such a track, passes from a tangent to a curve, or the reverse, it receives a shock of greater or less severity in proportion to the sharpness of the curvature. This shock is the cause of discomfort to passengers, of danger of derailment, and of injurious wear and tear of rolling stock and track. Both good policy and true economy dictate that these evils should be remedied as far as possible, by the removal of their cause, if it can be done without too great cost. Especially is this the case when the desired result can be obtained without any additional cost except that of a very small amount of labor on the part of the locating engineer.

Since the cause of the shock is evidently the inability of the moving train to adapt itself instantaneously to an abrupt change of direction, the remedy must just as evidently be sought in such a modification of the alignment of the track as will enable this change of direction to be made gradually.

The only satisfactory solution of this problem is obtained by introducing between the tangent and the curve, another curve of greater radius and easier curvature. Such a curve is called a "transition," or "easement," or "taper" curve, or "curve of adjustment."

Both the evil and the remedy have long been known to intelligent engineers, but it must be confessed, to the discredit of the profession, that the application of the remedy was, until quite

recently, left almost universally to the wisdom of the track foreman, and is still largely so left. This gentleman proceeds, with no guide but his judgment, to throw the track inward opposite the original point of curvature, extend the curve backward along the tangent, as far as he thinks proper, and then connect it with the original curve as best he can by eye.

This, of necessity, introduces a short piece of curvature sharper than the original, and is a very crude, unscientific, and unsatisfactory operation; but it is the best that can be done so long as it is postponed until after the track is graded. To be correct and effectual, the remedy must be applied before the grading is commenced, since it involves a modification of the alignment of the entire curve, and therefore falls within the duty of the locating engineer.

Of late years the importance of this subject has become generally acknowledged by the engineering profession, and many of its members are applying more or less correct scientific principles to its treatment. There are still very many, however, who entirely ignore it, and, as the writer believes, very largely for the reason that the transition curve has been usually shrouded in so much mathematical mystery that engineers who are not expert mathematicians have been discouraged from attempting to use it. If the writer can succeed in brushing away a part of this mystery, and in showing that any man who is mathematician enough to lay out a circular curve, can also lay out transition curves with almost equal ease, and thus aid in bringing about their more general adoption, the object of this paper will be accomplished. A brief preliminary study of the principles involved and the methods generally employed, will be useful.

Let us suppose a tangent $A\ B$ and a circular curve $B\ C$ to be located in the usual manner, B being the $P\ C$, or point of curvature.

Since from the requirements of the case any true easement curve should have a larger radius than that of the curve with which it is to connect, it follows evidently that no such curve can be introduced between the given tangent and curve which will be tangent to both of them, without moving either the main curve or the tangent a certain distance inward toward the center of the curve. In practice it is usually the curve which is so moved, and the amount of movement is called the "shift of the curve," which

we will designate by S. It is for this reason that easement curves should always be introduced before the grading is done.

There are several different forms of easement curves in use in this country, which may be classified under three heads.

1. A single simple circular curve of larger radius than that of the main curve.

This form is advocated by so high an authority as W. H. Brown, Esq., Chief Engineer of the Pennsylvania Railroad, and perhaps by others, but does not appear to be very extensively used. It is certainly very much better than nothing, and may in many cases be sufficient; but it is not the best either in theory or practice. In using this form, we may either leave the original $P\ C$ unchanged and shorten the radius of the central curve, or the starting point of the easement curve, which we will call the $P\ T\ C$, may be moved back along the tangent to some point A, and the radius of the central curve remain unchanged. In the first case, the formulas given by Henck (Sec. 81) may be employed: —

Let I = the central angle of the original curve.
R = the radius " " " "
D = the degree of curvature " " " "
R_1 = the assumed radius of the easement curve (which must be greater than R), D_1 = its degree of curvature, and n_1 its length in stations of 100 feet. R_2 = the radius, D_2 = the degree of curvature, and n_2 = the length of the new central curve Then —

$$R_1 - R_2 = \frac{(R_1 - R)\ \text{Sin}\ \frac{1}{2}I}{\text{Sin}\ (\frac{1}{2}I - n_1 D_1)} \qquad (1)$$

$$n_2 = \frac{I - 2n_1 D_1}{D_2} \qquad (2)$$

In the second case, the following approximate formulas for the value of S may be convenient: —

$$S = \tfrac{7}{8} n_1^{\,2}\ (D_1 - \tfrac{D}{4}) \qquad (3)$$

If $D_1 = \frac{D}{2}$, which theory would indicate to be its best value, this formula becomes —

$$S = \tfrac{7}{32} n_1^{\,2} D \qquad (4)$$

If in addition we make $n_1 = 2$, which will hereafter be shown to be a very convenient value,

$$S = \tfrac{7}{8} D \qquad (5)$$

2. A compound curve made up of several arcs having chords of equal lengths, and of regularly increasing degrees of curvature.

Easement curves of this form are usually called "taper curves," and are in much more general use than the preceding form. Engineers who use them differ considerably in the methods which they employ in setting them out, and in the values which they give to the lengths and deflection angles of the equal chords.

Wm. Hood, C. E., uses chords 30 feet long (or one rail length), and employs three different tapers, according to the degree of curvature of the central curve. The first changes 0° 30′ to each 30 feet, the second 1° to each 30 feet, and the third 2° 30′ to each 30 feet. The curve is set out by deflection angles, with a transit. The formulas and tables for this method may be found in "Engineering News," Vol. XX, pp. 42 and 60.

The method employed by Willard Beahan, C. E., is similar to Hood's, but uses chords 50 feet in length. The curve is set out by deflection angles. His formulas and tables may be found in "Railroad Gazette," Vol. XXI, page 352.

A. L. Mills, C. E., uses successive arcs of 1°, 2°, 3°, etc., curve, but varies the length of the equal chords according to the degree of curvature of the central curve, from 100 feet for a 3° 30′ curve, or less, to 30 feet for a 6° 31′ curve or more. The curve is set out by offsets from the tangent. His formulas and tables may be found in "Engineering News," Vol. XX, page 133.

A. M. Wellington, C. E., in the "Railroad Gazette," Vol. XIII, page 143, gives a method which is similar to that of Mr. Mills, in the use of offsets in setting out the curve, but employs chords of either 50 or 25 feet, and degrees of curvature changing either 0° 30′ to 50 feet, 1° to 50 feet, or 1° to 25 feet. He gives full rules and tables of offsets for the use of this method in the article referred to. Under this head will also come the methods given in some of our engineering field books for substituting a five-centered curve for a single circular curve.

Curves of this form do not meet precisely the theoretical requirements of the case, but when the chords used are not too long and the changes of curvature not too abrupt, the approximation is sufficiently close for all practical purposes. They are all, however, subject to the serious objection that they require the use of somewhat complicated formulas, and either elaborate tables of offsets or deflections, or frequent movements of the transit at the expense of considerable loss of time. If the locating engineer happens to find himself in the field without these formulas or tables, he will be

completely at sea, unless he is a sufficiently expert mathematician to calculate them for himself on the spur of the moment, with great liability to error. For this reason, this form of curve is not to be recommended for general use.

3. The third form of easement curve is what is commonly called a "spiral," and is a curve whose radius commencing with infinity at the junction of the curve with the tangent (*P T C*), gradually diminishes until at the junction with the central curve (*P C C*) it is equal to the radius of that curve. A curve of this form meets exactly the theoretical requirements of a transition curve. It also meets in the best possible manner another practical want.

When a train is moving on a curved track, the centrifugal force causes a constant tendency to mount the rail and leave the track on the outer side. This tendency is overcome in practice by elevating the outer rail sufficiently to counteract the centrifugal force by creating an equal tendency to slide inward under the action of gravity. The centrifugal force, and consequently the elevation of the rail, is proportional to the degree of curvature, and where a track is formed as usual, of a tangent and single circular curve, theory requires that at the point of curvature the outer rail should have the *full elevation* due to the *curve*, and at the same time *no* elevation at all for the tangent. This of course is impossible, and in practice the elevation is run out along the tangent at the rate of about 50 feet for each inch of elevation. This practice introduces elevation where it is not needed, and is an evil only less than the one it is intended to remedy, and therefore ought, if possible, to be avoided. This is done in the most perfect manner by introducing a transition curve in which the elevation, beginning at *O* at one end of the curve, increases uniformly until at the other end it is equal to the full amount due to the central curve, and the radius of which is at every point exactly proportional to the elevation. Any form of easement curve meets both of these requirements approximately to a greater or less degree, but the spiral is superior to all others in this respect, and for this reason its universal use is to be recommended, provided the difficulties which have discouraged its use can be removed.

The form of spiral most commonly used and most nearly conforming to the theoretical requirements of our problem, is the cubical parabola. It would take up too much space in this paper

to enter upon the study of this curve and of the various methods employed for laying it out on the ground. Those who may wish to do so will find very interesting discussions in the "Railroad Gazette," Vol. XXI, pages 1 and 93, and Vol. XII, page 639; in "Engineering News," Vol. VIII, pages 214 and 246, and "Clemens's Railroad Engineer's Practice," and also a very similar curve called Froude's curve of adjustment in that well of engineering learning, "Rankine's Civil Engineering." In "Engineering News," Vol. XXIII, Mr. A. M. Wellington entered upon a discussion of the subject which, if completed, might have made this paper unnecessary, but unfortunately, he stopped short before reaching the practical application of his ideas.

It will be sufficient for our purpose to take the three following equations, which express the properties of the curve: —

$$Y = \frac{X^3}{6lR} \tag{6}$$

$$O = \frac{l^2}{6R} \tag{7}$$

$$S = \frac{l^2}{24R} \tag{8}$$

In these equations, X is the abscissa and Y the ordinate of any point on the transition curve, the abscisses being measured from the $P\,T\,C$, or origin of the curve, along the tangent produced, and the ordinates measured from the tangent and at right angles to it; O is the ordinate of the terminal point, or $P\,C\,C$ of the curve, l is the length of the curve, and R is the radius, and S the shift of the central curve.

We also have the following equation expressing the theoretical relations between the length of the transition curve and the elevation of the outer rail and the slope which it is necessary to give to this rail to reach this elevation: —

$$l = ei \tag{9}$$

In this equation, e = elevation in feet, i = the distance in which the rail rises one foot. Another property of the curve which we must use, is that half the length of the curve must lie on each side of what would be the $P\,C$ of the circular curve, if there were no transition curve.

If we make D = the degree of curvature of the central curve, then we have —

$$R = \frac{5730}{D} \tag{10}$$

From equation (9), it appears that theoretically l is proportional to e and i, and since in practice and theory e is made proportional to D (within certain limits), l should vary with D. The attempt to conform to this condition, is the cause of nearly all of the difficulty that is met with in the use of the cubic parabola. It may be almost entirely avoided by giving a *constant* value to l.

This will have no effect upon the accuracy of the curve, for formulas (6), (7), and (8) will remain unchanged, and the curve will still be a perfect cubic parabola with varying proportions. Formula (9) is not a fundamental one, but is necessary only to adapt the curve to meet the requirements of an *extreme case*. Hence if we adopt a value of l, which is the proper one for *extreme* values of e and i, the same value may be used for all *other* values of e and i, with no other effect than that the resulting transition curve will be easier than in the extreme case, which cannot be considered a fault.

For the extreme or maximum value of e, few if any railroads in this country use a greater elevation than 8 inches or $\frac{2}{3}$ foot. For the extreme or minimum value of i, Froude (quoted by Rankine with apparent approval) recommends 300 feet, or 1 inch rise in 25 feet. Substituting these values in equation (9), we have —

$$l = 200 \text{ feet.} \qquad (11)$$

The engineers of the Pittsburgh, Cincinnati, and St. Louis Railroad are said to use a value of $i = 720$, or 1 inch rise in 60 feet, which would make $l = 480$ feet. This would of course make an easier transition curve; but in a country where it is necessary to use curves so sharp as to require the maximum elevation (which, according to the latest practice of 1 inch elevation to each degree of curvature, would be 8° or more), it would often be impossible to find room for the two adjoining transition curves of so great length, while it would very seldom occur that a length of 200 feet could not be obtained, and the much greater simplicity of the field work makes it a very convenient length.

To find the $P\ T\ C$, or starting point of the transition curve, we first find the intersection of the tangents and the angle of intersection ($= I$) in the usual way; then since half the length of the curve must lie on each side of the original $P\ C$, we find the apex distance of the $P\ C$, for the proposed $D°$ central curve, and the angle I, either by the formula $T = R \times \text{tang. } \frac{1}{2}I$, or by the tables of apex distances, which are now to be found in all modern field

books, and add $\frac{l}{2}$ l–$\frac{1}{2}$ l = 100 feet. The sum will be the apex distance of the $P\ T\ C$.

If in equation (8) we substitute for R its value, $\frac{5730}{D}$, and for l its value, 200, we have —

$$S = 0.291 \times D \qquad (12)$$

This is the distance which the central curve is to be thrown inward toward the center. If the line has already been located in the usual manner, and it is desired to substitute a transition curve before setting the slope stakes, this can be done without the use of a transit, by simply moving the central stakes inward a distance equal to S, and for this purpose it will be sufficiently accurate to call $S = 0.3\ D$, a value very easily remembered. If a locating engineer is very much hurried, or is not perfectly familiar with the setting out of transition curves, it might be advisable to make the location in the usual manner, and leave the revision to some leisure moment. This is another point in which this is the most convenient form of transition curve.

By making the same substitutions in equation (7), we obtain for the ordinate, or offset from the tangent, of the $P\ C\ C'$ —

$$O = 1.164 \times D. \qquad (13)$$

This is evidently equal to $4S$.

From equation (6) we observe that the offsets, or ordinates at intermediate points on the curve, are proportional to the cubes of the abscisses or distances of the points from the $P\ T\ C$ measured along the tangent. Making these distances (or x in the formula) successively $\frac{1}{8}l$, $\frac{2}{8}l$, $\frac{3}{8}l$, $\frac{4}{8}l$, $\frac{5}{8}l$, $\frac{6}{8}l$, $\frac{7}{8}l$, and l, which gives points at intervals of 25 feet, we have for the successive values of the offsets,

$\frac{1}{512}O$, $\frac{8}{512}O$, $\frac{27}{512}O$, $\frac{64}{512}O$, $\frac{125}{512}O$, $\frac{216}{512}O$, $\frac{343}{512}O$, and O;

or, .00227D, .018D, .061D, .145D, .284D, .491D, .779D, and 1.164D.

The transition curve may be set out by means of these offsets, and for this reason it would be well for the engineer to keep in his note-book a table of the above values of y, though the manner in which they are obtained is so plain that with a very little practice they can be easily calculated in the field if necessary.

This, however, is not a very convenient method of setting out the curve, though it may be useful for setting over the stakes of that portion of a line located in the usual manner, which lies opposite the transition curve. For this purpose the following table may be convenient: —

TABLE I.

Distance of point from $P\ T\ C$.	Offset.		
	Tangent to transition curve.	Tangent to original line.	Original line to transition curve.
25 feet	$.00227 \times D$	0.0	$0.00227 \times D$
50 "	$.018 \times D$	0.0	$0.018 \times D$
75 "	$.061 \times D$	0.0	$0.061 \times D$
100 " $= P\ C$	$.145 \times D$	0.0	$0.145 \times D$
125 "	$.284 \times D$	$0.054 \times D$	$0.230 \times D$
150 "	$.491 \times D$	$0.218 \times D$	$0.273 \times D$
175 "	$.779 \times D$	$0.491 \times D$	$0.288 \times D$
200 "	$1.164 \times D$	$0.873 \times D$	$0.291 \times D$

Column 2 contains the offsets from the tangent to the transition curve, as given above; column 3, the offsets from the tangent to the original curve calculated by the formula $O = \frac{1}{8}n^2D$, in which O is the offset, and n the distance from the $P\ C$ in stations of 100 feet; and column 4, the differences between these offsets, or the distance from the original line to the transition curve. In case of necessity, this table can be easily calculated in the field.

A much simpler and better method of setting out this curve, is by deflection angles with the transit. It is true that if the distances are measured along the curve by chords, as would naturally be done, the curve ceases to be a cubic parabola, and becomes what Rankine calls Froude's curve of adjustment; but within all ordinary limits of railroad practice, the two curves are so nearly identical that they may be regarded as such without sensible error.

Supposing the transit to be setting at the $P\ T\ C$, and calling the deflection angle from the tangent to any point of the curve, a, we have evidently —

$$\text{Tang. } a = \frac{y}{x} = \frac{x^3}{6lR} \div x = \frac{x^2}{6lR} = \frac{x^2D}{34380 \times l} \qquad (14)$$

From this equation it appears that tangent a varies as x^2 and D. Since within all ordinary limits of the value of D an angle varies very nearly as its tangent, we may say without material error that for all practical purposes the angle of deflection from the $P\ T\ C$ to any point on the transition curve will vary directly as the degree of curvature of the central curve, and as the square of the distance of the point from the $P\ T\ C$. Hence if we have the value of a for the terminal point of the curve (or the $P\ C\ C$), for $D = 1°$, all other

values can be calculated with perfect ease in the field, or tabulated if preferred.

For this terminal point we have from equation (14), since $x = l$, $D = 1$, and $l = 200$.

$$\text{Tang. } a = \frac{x^2 D}{34{,}380 l} = 0.005817. \tag{15}$$

$$a = 0° 20' = \tfrac{1}{3} D°. \tag{16}$$

This is a very simple and easily remembered expression. We can now readily obtain the following values of a for points along the curve at intervals of 25 feet: —

TABLE II.

Distance from P T C.	*Deflection angle.*
25 feet	$\frac{1}{192} D°$.
50 "	$\frac{4}{192} D° = \frac{1}{48} D° = 1\frac{1}{4}' \times D$.
75 "	$\frac{9}{192} D° = \frac{3}{64} D°$.
100 "	$\frac{16}{192} D° = \frac{1}{12} D° = 5' \times D$.
125 "	$\frac{25}{192} D°$.
150 "	$\frac{36}{192} D° = \frac{3}{16} D° = 11\frac{1}{4}' \times D$.
175 "	$\frac{49}{192} D°$.
200 feet = P C C	$\frac{64}{192} D° = \frac{1}{3} D° = 20' \times D$.

Since the transition curve takes the place of 100 feet of tangent and 100 feet of curve on the original line, it is evident that the total central angle of the curve $= D°$. Hence after the $P\ C\ C$ has been set, if we set the transit over it, take a backsight to the $P\ T\ C$ and deflect $D° - \frac{1}{3} D° = \frac{2}{3} D°$, we will have the new tangent, from which the central curve can then be set out in the usual manner. If after deflecting from the $P\ T\ C$ $\frac{1}{3} D°$ to set the $P\ C\ C$, we leave the vernier clamped, and take the backsight at the $P\ C\ C$ with the vernier still reading $\frac{1}{3} D°$, we have only to deflect till it reads $D°$ to get the new tangent.

If, as may sometimes happen, the $P\ T\ C$ should be inaccessible, we may set up at the original $P\ C$ 100 feet farther forward on the tangent. Then since the abscissa of the $P\ C\ C$, when measured from this point, is half as great as when measured from the $P\ T\ C$, while the ordinate is the same, it is evident that the tangent of the deflection angle to the $P\ C\ C$ or (within ordinary limits) the angle itself, will be twice as great as when taken at the $P\ T\ C$. Hence deflect $\frac{2}{3} D°$ from the tangent, measure 100 feet, and set the $P\ C\ C$. Set up at this point, backsight to the $P\ C$, and deflect $\frac{1}{3} D°$, which will give the new tangent. The transition curve can then be set in backward. After setting out the central curve and reaching the $P\ C\ C$ at the other end, the second transition curve is to be set out.

from that point. The process is the reverse of the one just described, and the following table gives the deflections from the tangent to the central curve at this point to points on the transition curve 25 feet apart: —

TABLE III.

Distances from P C C.	*Deflection angle.*
25 feet	$\frac{2}{192}D°$.
50 "	$\frac{44}{192}D° = \frac{11}{48}D° = 13\frac{3}{4}' \times D.$
75 "	$\frac{6}{192}D° = \frac{21}{64}D°.$
100 "	$\frac{80}{192}D° = \frac{5}{12}D° = 25' \times D.$
125 "	$\frac{95}{192}D° = \frac{1}{2}D°$ n'rly $= 30' \times D.$
150 "	$\frac{108}{192}D° = \frac{9}{16}D° = 33\frac{3}{4}' \times D.$
175 "	$\frac{119}{192}D° = 37' \times D.$
200 feet $= P\ T\ C$	$\frac{128}{192}D° = \frac{2}{3}D° = 40' \times D.$

As this table is not readily calculated or remembered, except the deflections to the 100 and 200 foot points, it will be most convenient to set out only these two points from the *P C C*, and any other necessary points can then be set in from the second *P T C*.

If the *P T C* is inaccessible, set out from the *P C C* as much of the transition curve as is practicable, then deflect from the tangent to the central curve $\frac{1}{3}$ *D*°, measure 100 feet, and set the *P C*. Set up at this point, backsight to the *P C C*, and deflect $\frac{2}{3}$ *D*°, and the transit will then point along the tangent to the transition curve 100 feet back from the *P T C*.

In setting centers for track laying, it is well to put them 25 feet apart, but on location it will usually be sufficient to set them 100 feet apart. The whole process then becomes exceedingly simple, and it is only necessary to observe the following rules without any special tables at all: —

1. Find the apex and the intersection angle *(I)* and the apex distance *(T)* for the proposed *D*° curve in the usual manner. Then $T + 100$ will be the apex distance of the *P T C*.

2. Set transit at the *P T C*, and deflect from the tangent $\frac{1}{12}$ *D*° for the first chord of 100 feet, and $\frac{1}{3}$ *D*° for the second. This fixes the *P C C*.

3. Set at the *P C C*, backsight to the *P T C*, and deflect $\frac{2}{3}$ *D*°. This gives the tangent to the central curve.

4. Set out the central circular curve in the usual manner, making its angular length equal to $I - 2\ D°$.

5. At the end of the central curve (which is the second *P C C*), deflect from the tangent $\frac{5}{12}$ *D*° for the first 100 foot chord and $\frac{2}{3}$ *D*° for the second. This fixes the second *P T C*.

6. Set at the *P T C*, backsight to the *P C C*, and deflect $\frac{1}{8} D°$. This gives the tangent.

If the line has been located in the usual manner, and it is desired to fit in transition curves without changing the tangents, it will be best to set out the two transition curves first, and then fit in the central curve between them. The unavoidable small discrepancies of linear and angular measurement will then be thrown upon the central curve, where they will do the least harm.

If, as will often be the case, the *P T C* should come between regular stations on the located line, the proper deflections to such regular stations as may come on the transition curve may be calculated, if desired, by formula (14), but it will be much more convenient to leave out the stations, and set the stakes at regular distances from the *P T C*. The regular stationing can be resumed on the central curve.

Lines set out by this method can, on account of its simplicity and uniformity, be retraced with as much ease and accuracy as an ordinary circular curve, which could hardly be said with perfect truth of any other method.

This method of setting out transition curves was worked out by the writer for his own use, and, so far as he is aware, it has never before been published, though on this point he may possibly be in error. It was the result of a long effort to find some method which would be sufficiently accurate for practical use, and at the same time free from the intricate and troublesome formulas and tables which make all other methods forbidding, and one which the average transit man could use without being tempted to violate the third commandment. Like many other methods in use among engineers, it is only approximately correct; but the error is so small as to be practicably inappreciable, and the writer has found it so entirely satisfactory in his own practice, which includes much sharp curvature, that he now uses it constantly for all curves exceeding 2°.

Engineers who are expert mathematicians, and have the desire and leisure to make their work theoretically perfect, will probably prefer some other method; but to the younger and less expert members of the profession, and perhaps to others who are pressed for time, it is hoped that the extreme simplicity of this method may make it of some value.

E. W. MUENSCHER, *Chief Engineer, M. & G. R. R. R.*

THAT PROBLEM IN LAND SURVEYING.

SOMETIME in 1889, I received from G. A. Randall, of Oshkosh, Wis., a request to give him a method for retracing a meander line of the United States Survey, consisting of several courses between two meander posts. It was a problem which, in a general way, I had met with a great many times in my practice; and I sat down, without hesitation, to write a solution. Before I was half done, it dawned upon me that my practice hitherto had been all wrong. I also realized that no text book in my possession so much as hinted that there was any such problem.

I worked out a solution, and sent it to the gentleman; but it was by no means the best solution, as I found on further investigation. Last winter I presented the problem in another form to this Society, and published it in the "Annual," with a request for solutions. I was then contemplating the issue of a revised edition of the "Manual of Land Surveying," and I wanted to get the best possible solution for use in the "Manual." I regret to say that I did not get any correct solutions, from any source, in time to make use of them in the "Manual;" and while it contains the problem and its solution, that solution is not by any means, in my opinion, the best. In my search for solutions from others, I presented the problem to several surveyors of my acquaintance, who in my judgment were the best qualified to give good ones. None of them succeeded until they had given it two or more trials. One of them who rides mathematics for his hobby, failed twice, and then told me that it could not be solved in the form in which I had given it. Then he went at it and worked out a first-class correct solution. He has been worrying and tearing that problem ever since, cuffing it this way and that, and dissecting it, until it does not seem possible there can be anything in its anatomy that he is not familiar with. He has sent me between 50 and 100 solutions, and has more left.

In the meantime, I had sent it to several of the engineering journals. The *News* at first refused to publish it, on the grounds

that it was a poorly concealed advertisement of the "Manual," and that it was not intricate enough for their columns, any way. So I made an advertisement of it in the *News*. Something over fifty persons responded to the publication in these journals, of whom only nine sent correct solutions. Among those who failed were a professor of civil engineering in a State university, a lieutenant of engineers in the United States army, the senior assistant engineer of an Eastern railroad, and a very prominent Canadian engineer and surveyor. All this is mentioned simply as showing the grounds for my belief that the correct solution of this problem by surveyors is the exception rather than the rule. Where land is very valuable, as it is in a great many cases where the solution is called for in locating boundaries, it is highly important that the solution should be a correct one. I submit four solutions by different parties, and will add that the easiest and shortest one I know of is a graphical solution suggested by H. C. Pearsons, who, if present, will readily demonstrate it.

SOLUTION NO. 1, BY F. HODGMAN.

PROBLEM: *To correct a random traverse of several courses between two known points.*

To solve the problem, we need a convenient basis of comparison between the courses and distances of the true line and those of the random. This will best be found by calculating the courses and distances of lines which will join the starting and closing points of the two surveys, calculating both as they would be according to the meridian and the measure of the random. It is better to calculate these in terms of the random, because of the greater convenience to the surveyor in applying his corrections in the field.

Preliminary Propositions: 1. A difference in length of the chains on different surveys by the same notes from a common starting-point, causes a difference in the length of the respective courses, without changing their direction. Hence, the closing points of the several surveys will all lie in one straight line with the common starting-point, and the relative length of the several chains is shown by the distances of the closing points from the common starting-point.

2. The effect of using different meridians (or variation of the needle) in such a case, is to swing the lines around the starting-point as a center, without changing the lengths of the courses, or

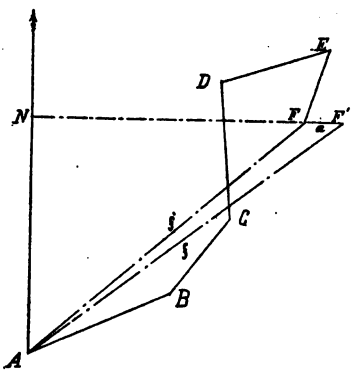
their angles with each other. Hence if chains are of equal length, the termini of the surveys will all lie in one arc, having the common starting-point for their center.

3. Hence the position of the terminus of a random, with relation to such a line and arc, passing through the terminus of the true line, determines both the difference in length of chains and of the meridians of the two surveys.

Let A, B, C, D, E, F, represent a true line of several courses, and F' the terminus of a random run from A to retrace the line, the course and distance of the line $F F'$ being known.

From A draw $A F$ and $A F'$.

The angle $F A F'$ measures the difference in courses, or, in other words, the correction for variation of the needle.



The length of the lines $A F$ and $A F'$ measures the comparative length of the chains used on the two surveys. $\frac{A F}{A F'}$ is the length of the chain used on the true line in terms of the chain used on the random.

The course of any part of the broken line, as $A B$ (in terms of the random) is equal to the bearing, by the original notes $\mp$ the angle $F A F'$.

The length of any course, as $A B$ in terms of the random, is equal to the length given in the original notes $\times \frac{A F}{A F'}$.

To find the correction to be applied to the stakes in the angles of the random, first compute the total latitude and departure of each of the points in the random line.

Second, convert the notes of the true line into terms of the random by changing the bearings and lengths of the several courses, and giving them as they would be according to the meridian and chain of the random, and compute the total latitudes and departures of the several points.

A comparison of the two results will give the correction to be applied at each stake of the random.

Example: A highway between nearest known points is described as follows: N. 62° E., 14 chains; N. 43½° E., 8 chains; N. 5° W., 12 chains; N. 72½° E., 10.25 chains; S. 12° W., 6.43 chains.

A random run with variation of needle 2° 17′ E. came out 62 links east of the point. Stakes were set at the angles of the random.

1. What is the variation of the needle as referred to the meridian of the original survey of the highway?

2. How much, and in what direction, must the stakes in the angles of the random be moved, to place them in the angles of the original line?

	N.	S.	E.	W.	Total Lat.	Total Dep.
1. N. 62° E., 14.00	6.57	....	12.36	....	6.57	12.36
2. N. 43½° E., 8.00	5.80	....	5.51	....	12.37	17.87
3. N. 5° W., 12.00	11.95	....	....	1.05	24.32	16.82
4. N. 72½° E., 10.25	3.08	....	9.78	....	27.40	26.60
5. S. 12° W., 6.43	....	6.29	....	1.34	21.11	25.26

Tan. $F'AN = \frac{NF'}{AN} = \frac{25.26}{21.11} = 1.19663 = \tan. 50° 7'$. $\therefore AF'F = 39° 53'$.

$AF' = \sqrt{AN^2 + NF^2} = \sqrt{21.11^2 + 25.26^2} = 32.92$. $FF' = .62$.

In the triangle AFF' we now have two sides and the included angle to find the remaining parts. We will call the angles AF and F', and the sides opposite, af and f'.

$$f + a : f - a :: \tan. \frac{F + A}{2} : \tan. \frac{F - A}{2}.$$

$$32.92 + 62 : 32.92 - 62 :: \tan. \frac{140° 07'}{2} : x;$$

or 33.54 : 32.60 : : 2.75621 : 2.65431, whence $x = \tan. 69° 21½'$.

$$A = 70° .03½' - 69° .21½' = 42'.$$

As the random came out east of the true line, the correction 42′ must be added to the assumed 2° 17′, to find the variation of the needle from the meridian of the original survey = 2° 59′ E. This will only need to be used in case the line is to be run over again.

To find f': Sin. A : Sin. F' : : 62 : f'.

.01222 : .64123 : : 62 : 32.446.

The length of the original chain in terms of the chain used in the random =

$$\frac{f}{f'} = \frac{32.446}{32.92} = .9856.$$

We will now apply these corrections to the original notes, reducing them to the meridian and measure of the random, and again compute total latitudes and departures.

	N.	S.	E.	W.	Total Lat.	Total Dep.
1. N. 61° 18′ E., 13.80	6.63	....	12.10	....	6.63	12.10
2. N. 42° 48′ E., 7.88	5.78	....	5.35	....	12.41	17.45
3. N. 5° 42′ W., 11.83	11.77	....	....	1.17	24.18	16.28
4. N. 71° 48′ E, 10.10	3.15	....	9.60	....	27.33	25.88
5. S. 11° 18′ W., 6.34	....	6.22	....	1.24	21.11	24.64

The last course is computed simply as a check to prove the correctness of the work, which it does. We now compare results to find the corrections to be applied to the stakes in the random to place them in the true line.

	B.		C.		D.		E.		F.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
Random Line	6.57	12.36	12.37	17.87	24.32	16.82	27.40	26.60	21.11	25.56
True Line	6.63	12 10	12.41	17.45	24.18	16.28	27.33	25.88	21.11	24.64

Stakes are to be moved as follows: At B, North, .06; West, .26; at C, North, .04; West, .42; at D, South, .14; West, .54; at E, South, .07; West, .72 — at F, West, .62.

If it is desirable to correct the stakes by measuring a single course and distance, we may solve these small right triangles.

Taking the first one at B, $\sqrt{6^2+26^2} = 26.7$. $\frac{26}{6} = 4.333+ =$ tan. 77°; hence the correction is N. 77°, W. 26.7 links. At C it is N. 84° 34′, W. 45½ links. At D, S. 75° 28′, W. 55.6 links. At E, S. 84° 27′, W. 73.3 links.

It will be noticed that in this particular example the angular correction can easily be found by subtracting the angle NAF from NAF'.

SOLUTION No. 2, BY F. A. STEIGER.

The solution is embodied in the following table: —

a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
Station.	Course.	Distance.	Lat.	Dep.	Total Lat.	Total Dep.	$\frac{g}{f}$
Stake *A*.....	N. 62° E.	14.00	+ 6.57	+12.36	+ 6.57	+12.36	1.881
" *B*.....	N. 43½° E.	8.00	+ 5.80	+ 5.51	+12.37	+17.87	1.445
" *C*.....	N. 5° W.	12.00	+11.95	— 1.05	+24.32	+16.82	.692
" *D*.....	N. 72½° E.	10.25	+ 3.08	+ 9.78	+27.40	+26.60	.971
" *E*.....	S. 12° W.	6.43	— 6.29	— 1.34	+21.11	+25.26	1.196
Stone No. 3	West.	.62	0.00	— .62	+21.11	+24.64	1.167

a	*i*	*j*	*k*	*l*
Station.	Courses.	$i +$ Constant angle	$\frac{n}{m} \times \frac{g}{\sin i}$	$\frac{g}{\sin i}$
Stake *A*.....	N. 62° E.	N. 78°–6′ W.	.26	.....
" *B*.....	N. 55°–19′ E.	N. 84°–47′ W.	.41	.....
" *C*.....	N. 34°–41′ E.	S. 74°–35′ W.	.56	.....
" *D*.....	N. 44°–10′ E.	S. 84°– 4′ W.	.72	.....
" *E*.....	N. 50°– 6′ E.	West.	.62	32.92
Stone No. 3	N. 49°–25′ E.	.....	...	32.46

Columns *a*, *b*, *c*, *d*, *e*, *f*, and *g* need no explanation. In column *h* the total departure of each course is divided by its total latitude, giving the tangent of the angle which a line connecting the extremity of that course and the starting point makes with a north and south line. In column *l* this angle is given, with its proper naming, so that we have the courses of the lines connecting with the starting point. In column *j* we have this course affected by a constant angle. This constant angle is found between the lines connecting the starting point, and stone 3 of the original survey, with stake *E*. The courses given in column *j* are *the courses to be used in shifting the stakes from their positions in the new survey to their positions in the original survey.*

Column *k* gives *the distance that each stake is to be moved.* These distances are proportional to the distances of the stakes from the starting point. In the expression, $\frac{n}{m}\left(\frac{g}{\sin i}\right)$, m is the distance of stake *E* from the starting point (32.92), and n is the error of closing (62 links).

The closing course and distance (west 62 links) are included in the table. The angular difference between the last two courses in column *i*, 41′, is *the required error of variation.*

In column *l* the distances between post 5 and stake *E*, and between post 5 and stone 3 $\left(\frac{g}{\sin i}\right)$ of the last two courses, are given. The difference (46 links) between these distances, when taken in connection with the distance (32.92 chains) from post 5 to stake *E*, gives *the proportional error of measurement.* In this example this error is 1.4 links per chain.

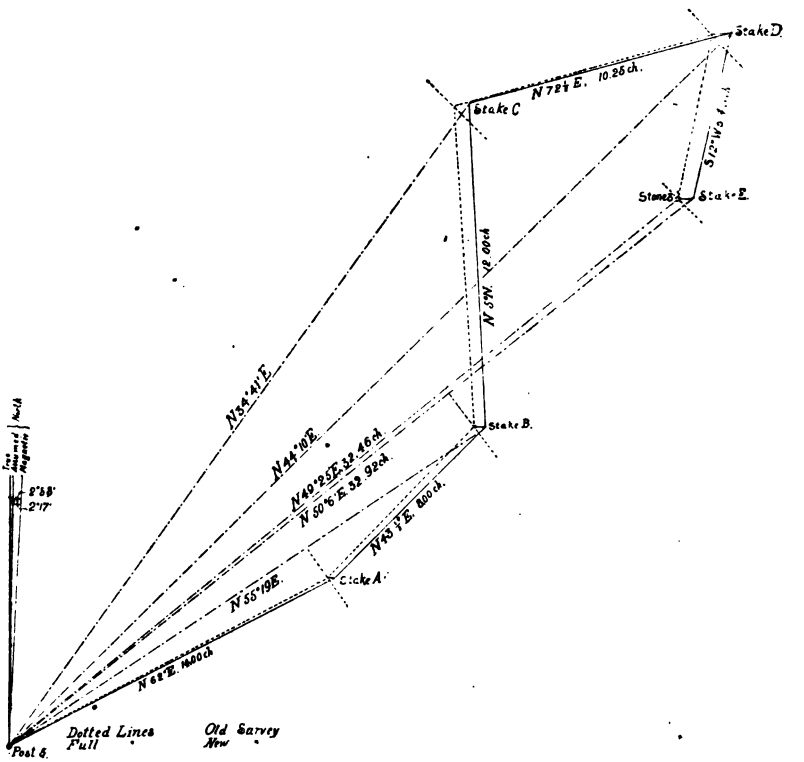
The general problem has three cases: —

1. When the error is all due to a difference in magnetic variation used.

2. When the error is all due to a proportional difference in measurements.

3. When the error is due to differences both in variation and measurements.

If the error were all due to variation, the points of the new survey would fall on arcs of circles passing through the corresponding



points of the old survey, and having the starting point as a common center. The amount of arc included between the old and the new points would measure the error of variation. The chords of these arcs would be proportional to the distances of the points from the starting point, and their lengths could be found when we knew the closing distance, which, in this case, would be a chord of one of the arcs. These chords make constant angles with the lines to the starting point, and their courses can be determined after we have determined the courses of these lines from the total

latitudes, and departures of the points which they connect with the starting point (as in this case).

If the error were all due to a proportional difference of measurements, the points of the new survey would fall on lines connecting the corresponding points of the old survey with the starting point. The distances between the old and new points would be in proportion to the distances of the new points from the starting point, and could be found when we knew the closing distance, which in this case would fall on the line connecting the last station with the starting point.

If the error were due to both a proportional difference of the measurements and a difference of the variation used, the points of the new survey would fall neither on the arcs through the corresponding points of the old survey nor on the lines connecting these points with the starting point.

We have found that the corrections for variation and for measurements are both proportional to the distances of the new points from the starting point — that the directions of the lines correcting the measurements are along the lines connecting the new points with the starting point, and that the directions of the lines correcting the variation are such that they make constant angles with the lines connecting the new points with the starting point.

From these considerations it can easily be seen that the two corrections are proportional to each other — that they make a constant angle with each other — and, therefore, that a line connecting each new point with its corresponding old point will be in proportion to, and make a constant angle with, the lines connecting the new points with the starting point. Although we have three cases, the rule for making the corrections will be the same. Rule:

"Lay off from the new point, lines whose directions are such that they make the same angles with the lines to the starting point, as the closing line does with the line connecting the last station with the starting point, and whose lengths bear the same proportion to the lines to the starting point as the closing distance does to the line from the last station to the starting point."

We get the error of variation and the proportional error of measurements from the difference between the courses and the difference in lengths of the lines connecting the known point of the old survey and the corresponding point of the new survey with the starting point, which is common to both old and new surveys.

In an actual case, the amount of work would be greatly reduced by plotting the survey and scaling the angles and distances.

SOLUTION No. 3, BY S. W. FRESCOLN.

Designate successive corners by No. 5, *A*, *B*, *C*, *D*, No. 3.

Line.	*Bearing.*	*Distance chains.*	
No. 5 — *A*	N 62° E	14.00	
A — *B*	N 43° 30′ E	8.00	Assumed variation
B — *C*	N 5° 00′ W	12.00	= 2° 17′ E
C — *D*	N 72° 30′ E	10.25	
D — No. 3	S 12° 00′ W	6.43	Error of closure. Northings = 0 Eastings = 62 links.

The total error is due to a combination of *error in variation* and *error in chain.*

Let y = error in chain per chain.

Let $10x$ = correction to variation in minutes.

∴ Bearings of random line *differ* from bearings of true line by $10x$ minutes.

A table of nat. sines and cosines gives difference in cos and sin (or lat. and dep.) for each bearing due to a change of 10′; these values multiplied by x and the length of the course will hence produce the errors in lat. and dep. for that course due to the error in variation. In this manner form Table I.

TABLE I.

ERRORS IN LAT. AND DEP. DUE TO ERROR IN VARIATION.

Course	No. 5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—No. 3.
Lat.	—.036x	—.016x	+.002x	—.029x	+.004x
Dep	+.020x	+.017x	+.035x	+.009x	—.019x

Summing — Total error in lat. due to variation ..... = —.075x
" " " dep. " " " ..... = +.062x

Also length of each course multiplied by y and then respectively by cos and sin of bearing will produce the errors in lat. and dep. of each course due to error in chain. Thus form Table II: —

TABLE II.

ERRORS IN LAT. AND DEP. DUE TO ERROR IN CHAIN.

Course	No. 5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—No. 3.
Lat.	— 6.58y	— 5.80y	— 11.95y	— 3.08y	+6.29y
Dep	— 12.36y	— 5.50y	+ 1.04y	— 9.78y	+1.34y

Summing —
Total error in lat. due to error in chain..... = —21.12y
" " " dep. " " " " " " ..... = —25.26y

Resultant errors = sum of these two, and hence form

(Lat.) the equations : $-.075x - 21.12y = 0$ (1)

(Dep.) $+.062x - 25.26y = .62$ (2)

Solve and find $y = -.014$ (∴ chain is too long.)

$$x = 4.09.$$

∴ $10x = 41$ minutes ; corrected variation = 2° 58′ E.

Substitute values of x and y in tables 1 and 2, which as results are only wanted to nearest link, can in this and in most cases be done mentally, and then by simple addition find corrections for each station, as is clearly shown by following tables: —

TABLE III.

CORRECTIONS IN LINKS PER COURSE DUE TO VARIATION.

Course	5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—3
Lat.	+ 15	+ 7	— 1	+ 11	— 3
Dep.	— 8	— 7	— 15	— 4	+ 8

TABLE IV.

CORRECTIONS IN LINKS PER COURSE DUE TO CHAIN.

Course	5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—3
Lat.	— 6	— 8	— 17	— 4	+ 9
Dep.	— 17	— 8	+ 1	— 14	+ 2

TABLE V.

CORRECTIONS IN LINKS PER COURSE DUE TO BOTH.

Course	5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—3
Lat.	+ 1	— 1	— 18	+ 7	+ 6
Dep.	— 25	— 15	— 14	— 18	+ 10

TABLE VI.

CORRECTIONS IN LINKS PER STATION ; OBTAINED BY ADDING TO EACH COLUMN OF TABLE 5 THE SUM OF ALL THAT PRECEDES.

Station	*A*	B	*C*	*D*	No. 3
Lat.	+ 6	+ 5	— 13	— 6	0
Dep.	— 25	— 40	— 54	— 72	— 62

If the error in variation were simply desired without wishing the corrections per station, it can be obtained very simply, viz.: by dividing the total error of closure by the total distance, which will be the *sin* of the angular error, near enough for all practical purposes. In fact, it gives 42 minutes instead of 41 minutes, which of course is near enough.

Solution No. 4, by Edward A. Stockwell.

Let α = correction to the length of chain used on random line.

Let Θ = correction to the assumed variation of the needle.

Let x_0 and y_0 = departure and latitude of the true terminal point referred to the starting point as origin.

Let x_1 and y_1 = departure and latitude of the terminal point of the random line referred to the same origin.

Let the bearings be denoted by a, a', a'', a''', etc.

Let the number of chains in the corresponding courses be denoted by n, n', n'', n''', etc.

Then we shall have:

$$(1+\alpha)\, n \sin(a+\Theta) + (1+\alpha)\, n' \sin(a'+\Theta) + (1+\alpha)\, n'' \sin(a''+\Theta) + \text{etc.} = x_0 \quad (1)$$

$$\text{and } (1+\alpha)\, n \cos(a+\Theta) + (1+\alpha)\, n' \cos(a'+\Theta) + (1+\alpha)\, n'' \cos(a''+\Theta) + \text{etc.} = y_0 \quad (2)$$

$$\text{but } \sin(a+\Theta) = \sin a \cos\Theta + \cos a \sin\Theta,$$
$$\text{and } \cos(a+\Theta) = \cos a \cos\Theta - \sin a \sin\Theta.$$

Substituting these values in (1) and (2), and in the results substituting for $\cos\Theta$ the value $1 - 2\sin^2\frac{1}{2}\Theta$, we have —

$$(1+\alpha)[n(\sin a - 2\sin a \sin^2\tfrac{1}{2}\Theta + \cos a \sin\Theta) + n'(\sin a' - 2\sin a' \sin^2\tfrac{1}{2}\Theta + \cos a' \sin\Theta) + \text{etc.} = x_0 \quad (3)$$

$$\text{and } (1+\alpha)[n(\cos a - 2\cos a \sin^2\tfrac{1}{2}\Theta - \sin a \sin\Theta) + n'(\cos a' - 2\cos a \sin^2\tfrac{1}{2}\Theta - \sin a' \sin\Theta) + \text{etc.} = y_0 \quad (4)$$

$$\text{but } n\sin a + n'\sin a' + n''\sin a'' + \text{etc.} = x_1 \quad (5)$$

$$\text{and } n\cos a + n'\cos a' + n''\cos a'' + \text{etc.} = y_1 \quad (6)$$

Substituting these values in (3) and (4), we have —

$$x_1 + \alpha x_1 + \sin\Theta\, y_1 + \alpha \sin\Theta\, y_1 - 2\alpha\sin^2\tfrac{1}{2}\Theta\, x_1 = x_0 \quad (7)$$

$$\text{and } y_1 + \alpha y_1 - \sin\Theta\, x_1 - \alpha\sin\Theta\, x_1 - 2\alpha\sin^2\tfrac{1}{2}\Theta\, y_1 = y_0 \quad (8)$$

Since α and Θ are very small, we may put $\sin\Theta = \Theta$, and $\sin^2\frac{1}{2}\Theta = \frac{1}{4}\Theta^2$, and $\alpha\sin^2\frac{1}{2}\Theta = \alpha\frac{1}{4}\Theta^2 = 0$ by neglecting terms of the third order; substituting these values in (7) and (8) and reducing, we have —

$$\alpha + \frac{y_1}{x_1}\Theta = \frac{x_0 - x_1}{x_1} - \frac{y_1}{x_1}\alpha\Theta + \tfrac{1}{2}\Theta^2 \quad (9)$$

$$\text{and} \qquad \alpha - \frac{x_1}{y_1}\Theta = \frac{y_0 - y_1}{y_1} + \frac{x_1}{y_1}\alpha\Theta + \tfrac{1}{2}\Theta^2 \quad (10)$$

$$\text{from which} \qquad \Theta = \frac{x_0 y_1 - x_1 y_0}{(x_1^2 + y_1^2)(1+\alpha)} \quad (11)$$

Multiplying (7) and (8) by x_1 and y_1 respectively, adding and reducing we get

$$\alpha = \frac{x_1(x_0 - x_1) + y_1(y_0 - y_1)}{x_1^2 + y_1^2} + \tfrac{1}{2}\Theta^2 \quad (12)$$

$$\text{and} \qquad 1 + \alpha = \frac{x_0 x_1 + y_0 y_1}{x_1^2 + y_1^2} + \tfrac{1}{2}\Theta^2 \quad (13)$$

SOLUTION TO PROBLEM IN MICHIGAN ENGINEER'S ANNUAL, AUG. 16, 1890.

14 cos	62°	$= +$ 6.5726
8 cos	43½°	$= +$ 5.8029
12 cos	5°	$= +$ 11.9543
10.25 cos	72½°	$= +$ 3.0823
6.43 cos	$-$ 168°	$= -$ 6.2895
		$y_1 = +$ 21.1226
		$y_0 = +$ 21.1226

14 sin	62°	$= +$ 12.3613
8 sin	43½°	$= +$ 5.5068
12 sin	$-$ 5°	$= -$ 1.0459
10.25 sin	72½°	$= +$ 9.7757
6.43 sin	$-$ 168°	$= -$ 1.3369
		$x_1 = +$ 25.2610
		$x_0 = +$ 24.6410

$y_0 = y_1$

$x_0 = x_1 - 0.62 =$

$+$ 24.6410

Substituting these values in equation (11), disregarding α we have

$$\Theta = \frac{24.6410 \times 21.1226 - 25.2610 \times 21.1226}{25.2610^2 + 21.1226^2} = -0.012078$$

Substituting these same values in equation (12), we have

$$\alpha = \frac{25.2610 \times -0.62}{25.2610^2 + 21.1226^2} + 0.000075 = -0.01438$$

$$\text{and } 1 + \alpha = 1 - 0.01438 = +0.98562$$

$$\text{hence } \Theta = \frac{-0.012078}{0.98562} = -0.012255 = -0^\circ\ 42'\ 7''.8$$

and the magnetic variation $= -2^\circ\ 27' - 0^\circ\ 42'\ 7''.8 = -2^\circ\ 59'\ 7''.8$, *i. e.*, $2^\circ\ 59'\ 7''.8$ East.

Now, multiply the given length of each course by $(1 + \alpha) = 0.98562$ to get the length of true courses and add $-0^\circ\ 42'\ 7''.8$ to the preceding bearings, and we have —

13.7984 cos	61° 17′ 52″	$= +$ 6.6269
7.8848 cos	42° 47′ 52″	$= +$ 5.7857
11.8272 cos	5° 42′ 08″	$= +$ 11.7689
10.1024 cos	71° 47′ 52″	$= +$ 3.1558
6.3374 cos	$-$ 168° 42′ 08″	$= -$ 6.2147
		$y_0 = +$ 21.1226
13.7984 sin	61° 17′ 52″	$= +$ 12.1033
7.8848 sin	42° 47′ 52″	$= +$ 5.3732
11.8272 sin	$-$ 5° 42′ 08″	$= +-$1.1751
10.1024 sin	71° 47′ 52″	$= +$ 9.5972
6.3374 sin	$-$ 168° 42′ 08″	$= -$ 1.2416
		$x = +$ 24.641

Refer the latitude and departure of each station on both lines to the starting point, and we will get the following table of corrections: —

	Latitudes, rand'm line.	Latitudes, true line.	Correction.	Departure, rand'm line.	Departure, true line.	Correction.
			North.			West.
Sta. 1....	+ 6.5726	+ 6.6269	+ 0.0543	+12.3613	+12.1033	— 0.2580
" 2....	+12.3755	+12.4126	+ 0.0371	+17.8681	+17.4605	— 0.4076
			South.			
" 3....	+24.3298	+24.1815	— 0.1483	+16.8222	+16.2854	— 0.5368
" 4....	+27.4121	+27.3373	— 0.0748	+26.5979	+25.8826	— 0.7153
" 5....	+21.1226	+21.1226	0.0000	+25.2610	+24.6410	— 0.6200

Correct solutions have been received from Messrs. J. Foster Crowell, Horace Andrews, D. E. Hughes, Wm. M. Whitten, Victor C. Hills, and Hitt & Williams. F. HODGMAN.

THE SANDSTONES OF LAKE SUPERIOR.

GENERAL HISTORY.

WE must, in studying formations, constantly bear in mind that as a general proposition, all those portions of the earth's crust which were above water at any given period, were being cut down, and all those portions which were below water at that time, were being filled up. This is modified by the fact that submerged coast lands were being cut down by shore currents, and upland valleys were occasionally having temporary deposits in them; but these modifications were confined to spots, and were only temporary effects.

This accounts for the fact that, although the different rock formations are piled on top of each other like the leaves of a book, nowhere do we find the book complete. A portion of a leaf is torn out here, and another leaf is torn out there, and so on through the whole thickness of the book.

There is always enough left of any one leaf to show that such leaf existed, and this is made of the materials which were laid down under water during that particular age which it represents. The materials were taken from the uplands of that age, and were torn out of the exposed portions of the earlier leaves.

The rocks of the formations, *i. e.*, the sedimentary rocks, grow more and more homogeneous in composition as we leave the earlier tumultuous period, and approach the long periods of quietude of the later ages of the earth. In the early days, the minerals were all scattered promiscuously throughout the various rocks, and they were consequently of a very complex constitution.

By the slow and quiet operation of ages of weathering and watering, silica has been dissolved out, separated, and re-deposited in piles by itself as sandstone or quartzite; the aluminas and the limes and all the rest of the important minerals have gone through nature's crushing and grinding mills, and have been separated and assorted according to size and weight by nature's sluice-ways and other hydraulic processes. Apart from the mechanical operations of water, there have been vast chemical forces at work to break up the prime minerals so they could be assorted by hydraulic power, and it must be remembered that decomposition is as much a chemical process, as composition. We will consider three prime minerals only; feldspar, hornblende, and augite. The first contains silica, alumina, and an alkali, potash, soda, lime. Hornblende gives silica, iron, alumina, or other base, and augite gives silica, alumina, lime, magnesia, and iron. When the silica has been dissolved out of these and re-deposited as sandstone or quartzite, the other minerals are released and at liberty to form new partnerships and build new rocks.

As will be readily seen from the foregoing, the sandstone formations come under the head of secondaries in the earth's formations. We know very much more about these rocks than we do about the primaries; for we can get at the edges of these all around the whole area. They occur in spots, although to be sure the spots are as large as islands, and almost as continents, in some places. The top surface of the primaries is a surface composed of wrinkled and upturned edges of strata, upon which the calm and placid beds of the secondaries are laid down flat, thus showing sharp division lines.

Sandstone, as will be readily seen from the foregoing, is derived from the primary quartzite, which has been washed down and deposited in new beds during secondary times, and become hardened by time and pressure. The sandstones are found in beds all the way up at intervals throughout the whole secondary series, and the sands constitute at least three fourths of all the mass of mate-

rials in this formation. The principal differences to be seen among the beds are variations in the size of grains. There are four great plates of sandstone between the top of the primaries and the bottom of the great *coal measures*.

The Potsdam Sandstone lies on the primaries, and forms the crest and the western slope of the Blue Ridge.

The Medina Sandstone is the second, and forms the crest and western slope of North Mountain.

The Oriskany is the third great sandstone, and forms the crest and western slope of Capon Mountain, and others in that line of upheaval.

The Millstone Grit is the fourth great sandstone, and forms the base of the coal measures.

The Mahoning Sandstone is the plate that divides the coal measures into upper and lower coals.

The secondary rocks form the country rock of the Mississippi Basin, and they are also found in areas east of the Blue Ridge of the Appalachian Mountain Range. The eastern edge of the Potsdam sandstone caps the Blue Ridge from near Harper's Ferry down past Harrisburg, and on through Virginia and the Carolinas, thence past Cartersville, in Georgia, to the Coosa River in Alabama, near the Selma and Rome railroad bridge. In western North Carolina and southern Virginia, this stone has been terribly tossed up and broken through by the upheavals of the primaries, but it gets control again, and passes under the valley of East Tennessee.

The secondary rocks extend westward beyond the Mississippi to the Rocky Mountains, broken, of course, where the before-named primary upheavals come up through, but the further west they extend, the thinner they get. Rock beds which are hundreds of feet thick in the Appalachian Mountains are represented in Missouri by feather edged beds of but a few feet in thickness, while at the foot of the Rockies many beds are missing altogether.

There are detached areas of the secondary rocks east of the Blue Ridge, which although small, are of great value; for these areas furnish all the brown stone used in building in New York and other cities in the Eastern States. The stone comes from the triassic period of the secondary formation, which is found in troughs in the primary rocks all the way from Nova Scotia down to Georgia, the beds, however, not being found continuous. The northern slope of Nova Scotia is of this triassic age. Shalers'

quarries in Connecticut furnish nearly all the stone used in Boston, Providence, New York, New Haven, and Hartford. The red soils of New Jersey are underlaid with it, parts of the Susquehanna near York, and all the Monocassy Valley are of this formation. The Grant-Seneca quarries are of this formation, and the Virginia Midland Railroad runs across miles of it.

The Lake Superior region has extensive deposits of it, and they are rapidly becoming developed, and extensive quarries are being worked; and in the cities of the West and Northwest this material is rapidly growing in favor.

If we accept recent architectural work, as met with in our public buildings or private residences in cities and towns, as a criterion of the general sentiment in that direction, we shall find that the tendency is to leave the old method of building block after block in one style. Until recently, we have had a monotonous dull-colored variety of stone for facing, whether brownstone, amply illustrated by the general appearance of New York City, or the ordinary brick with marble trimmings, met with in Philadelphia.

We observe with pleasure costly palaces of every variety of design and execution beginning to loom up out of dull rows of monotonous houses. The corners of our principal thoroughfares are showing up landmarks in the shape of business structures, regular piles of masonry embodying the strength and solidity of massive stonework, while the external appearance is relieved by the facing and column work of granite, marble, or a fine variety of sandstone. The residential avenues are fast developing the general aspect of the more noted European cities in their pleasing variety of composition and elaboration.

And yet, after all, aside from the care bestowed upon the actual building operation and the artistic merit of the production, the building stone used, though playing a most important part, is sometimes chosen injudiciously. I have often seen beautiful structures rapidly approaching decay for no other cause than the employment of a stone unsuited to the nature of the work or the climatic condition of the locality. Some of the handsomest light-colored stones, only suited for interior decorative work, have been applied outside with disastrous results, while for a perhaps smaller expenditure a much more durable stone, of an appearance certainly just as elegant, though darker in color, could have been substituted.

The fault will probably lie, in the main, with the desire to obtain beauty at any cost. A judicious selection from a fairly large number of really good building stones that are available, will certainly result in better work and greater satisfaction ultimately to the owner.

In looking over the varieties of stone kept in stock in large establishments, it is found that poor varieties are kept solely because architects will build with them. As time passes on, however, and such buildings show unmistakable signs of decay, these kinds of building stone will be relegated back, and other more durable varieties of rich color or fine quality will come forward into general use.

The Potsdam sandstones of the Upper Peninsula offer a great variety both in color and fineness of grain, and are very extensive deposits; although the beds are not very thick, I have heard of the deposit being in some places 100 feet in thickness. They are, however, pretty generally defective, and a good reliable building stone is a hard thing to find, particularly of the finer and uniform grades of color. They are also in many places filled with large and small pebbles, forming a species of conglomerate with dry seams or strain cracks. These cracks are often imperceptible until after the stone is quarried. There are also clay seams and clay nodules in them that impair not only the looks but the durability of the stone. Another defect is iron seams which decompose, and not only stain, but detract from the strength and durability of the stone. Among the finest quarries being worked on Lake Superior at the present time are the Fuerst & Jacobs Company quarry, and the Portage Entry Red Sandstone Company. Both quarries are situated immediately adjacent to the Portage Entry. There are two qualities of stone in these quarries, the first and the second. The first quality is of an even, rich red color, perfectly uniform in grain, compact and without flaws, and is eagerly bought all over the country. Many public buildings, banks, churches, etc., and the Michigan Mining School at Houghton, are built of this stone.

The second quality of stone is of about the same composition, but the color is not a uniform red. It has white bands running through it, and makes what is termed a variegated stone. This also is an element of weakness in the stone, as the quartz crystals forming the white are a much harder formation than the red, and the stone is liable to split or fracture on these lines.

These different qualities of stone are found in distinct layers, and the work of quarrying them is therefore carried out with considerable certainty. An analysis of the stone gives the following composition:—

	Per cent.
Silica	94.73
Peroxide of iron	2.64
Alumina	0.36
Carbonate of lime	0.69
Carbonate of magnesia	0.75
Water	0.74
Losses, etc	0.09
	100.00

The very high percentage of silica, and relatively small proportion of other ingredients, makes it a remarkably pure sandstone, the peroxide of iron giving it its beautiful red color. These two quarries got out in the neighborhood of 900,000 feet of stone this year.

In speaking of these quarries, I cannot omit mentioning the original discoverer of them, as he is also the pioneer of the Lake Superior sandstone region, Mr. George Craig, now living at Chassell, Houghton county, Mich., born in Yorkshire, England, in 1819, near a town called Huddersfield, where his father owned one of the famous freestone quarries of that district. The son was brought up to the business, and followed it the rest of his life. He came over to the United States in 1854, and applied himself to quarry work both here and in Canada. He was the first to quarry and work the now famous quarries at Marquette in 1860, and the story of his labor to induce capital to take hold of such an enterprise as a stone quarry, would be both a long and interesting one. In 1871, he made an exploration for sandstones from White-fish Point to Iron River, Ontonagon, on the south shore of Lake Superior, examining the outcrop of the sandstone formations. This exploration was made in a small boat and under many difficulties, dangers, and privations. It was during this trip he discovered the now famous Portage Entry quarries, and bought the land where they are situated, which he held for fifteen years, before he could get capital to take hold of it with him to develop it. It is now the leading sandstone quarry of Lake Superior.

The next quarries in importance, and doing the next largest business, are the famous Prentiss quarries, situated near Ashland, Wis.; but although I have seen quantities of the stone, I have not

yet been able to visit the quarries, so I cannot give any particulars about them. There are also some quarries situated on the islands near Bayfield, that turn out some fairly good stone.

The Rock River quarries, situated on Au Train Bay, are rapidly coming to the front as the source of a remarkably fine building material. They are in color very similar to the Connecticut brownstones, and I think they will make, in time, one of the best quarries on Lake Superior. The analysis of the stone is as follows: —

BROWN SANDSTONE.

	Per cent.
Moisture	1.20
Silica	78.90
Alumina	10.56
Iron oxide	5.34
Manganese oxide	trace
Carbonate of lime	1.10
Magnesia	.38
Sodic oxide	1.01
Potassic oxide	.56
	99.05

WHITE SANDSTONE.

Moisture	1.35
Silica	86.25
Alumina	5.34
Iron oxide	2.64
Magnesia	.90
Carbonate of lime	2.65
	99.13

The proprietors of this quarry learned a severe lesson this fall, in losing considerable stone from quarrying too late in the season The majority of sandstones here cannot be quarried to exceed four months in the summer season, as the frost getting into the green stone, cracks it into small pieces, and the stone bursts. This does not occur, however, after the stone once gets seasoned, as it then absorbs but little moisture. As an instance, I have seen large blocks of stone that have lain, for the last twelve years, where part of them were submerged and part exposed to the weather where they had wave action; and yet the texture of the stone was not injured a particle.

The Detroit and Marquette Brownstone Company are opening up a very fine quality of brownstone on Keweenaw Bay, situated about 2½ miles from the village of L'Anse. This stone is of a very rich dark brown color, and almost identical with the old Marquette

brownstone. They have a very large deposit of it; and when they get their quarry properly opened up, I have no doubt they will be one of the largest producers on Lake Superior. The stone has all the requirements for a first-class building stone. (I shall send an analysis of stone later to the Secretary.) The crushing strength, according to tests at the United States Navy Yard, Washington, D. C., on 2″ cubes, are as follows: No. 1, 37.418 lbs.; No. 2, 42.582 lbs.; No. 3, 38.110 lbs.; No. 4, 39.349 lbs. The stone is easily worked when green, carving beautifully, and holding a sharp, strong edge, and stands well under the tool. I shall send a sample of this stone, if possible, to the Society.

I will now give an illustration of how money can be lost in quarrying here, and how capital was induced to spend a large amount of money through their own ignorance of the business, and the representations of unprincipled mountebanks, representing themselves as experts, when the veriest school-boy ought to know better. I allude to the property known as the Carp River quarries, and situated but a few miles from Marquette.

The Carp River Valley, in which the property is located, runs in an east and west direction for some distance, with a very rapid fall toward the lake, and is very narrow, being bounded on either side by large hills of quartzite, fissured in many places by veins carrying iron, on which considerable prospecting has been done. The sandstones overlay this quartzite formation, and are now very thin, and in my opinion were never very thick in this valley.

They were evidently left (by these markings) by very rapid moving water and wave action, and before the sands composing them acquired the consistency of stone, large and small bowlders of the original quartzite were rolled into them from the adjoining hights or were carried by water action from higher up the stream. (The stone, what there is of it, is a very pretty brown, but is spotted and blotched throughout with white spots of hard quartz silica, and alumina. This feature prevails in a greater or less degree throughout the whole district where I have examined, and makes it very difficult to obtain any very large deposit of pure red or brown stone.) The stone in this valley lies on the original or primary rock at an angle to the horizon of about 30°, and the beds in the quarries also bear this out, and show that the angle was made chiefly by settlement and not by erosion, as the beds lie almost parallel to the slope of the primary rocks. This ac-

counts for one of the peculiar defects which display themselves in this stone, as all the stone quarried here goes to pieces in irregular prisms almost immediately after being quarried, and shows that it is all lieing under severe strain; and it is this strain that produces the cracks which appear and make the stone so defective. The irregular action which originally placed the molecules together here, showing the wavy and folded layers and markings in the stone, are also an element of weakness. As they form lines of greatest weakness, the cracks follow them in their irregular curves and prisms. Stone of the character that is required for building purposes from the sandstone formations, should be taken from beds or layers which were deposited either in very sluggish water, or laid as a sedimentary deposit in flat and even layers, and in a district that shows tolerably few violent upheavals or settlements which might produce strain. Sandstone laid down in large deposits being massive in its beds and lieing comparatively flat to the horizon, will prove to be generally finer in texture, even in their lines of cleavage and breakage, and more generally homogeneous. True, they frequently carry clay streaks, but this does not always prove a defect, and often proves a benefit in relieving pressure, and making the stone slip on its bed easier. As will be seen by the foregoing, the property just mentioned had none of these features, and from a careful examination of the property and all openings made in its vicinity, I came to the conclusion that there was not a cubic foot of good sound merchantable stone on the entire property. Yet railroads were built, machinery bought, put in place, and operated; and shops, boarding houses, stables, and other buildings erected at great expense; all before hardly any work had been done to prove whether they had a quarry or not; and they never were able to get a ton of sound rock from the location.

There are many explorations being made here for sandstones by both experts and mountebanks, and almost every homesteader in the district claims to have a stone quarry on his location. There is a large amount of money being spent both wisely and foolishly in this business; and although it will result in very many failures, the indications are that some very valuable deposits will be located, and good quarries opened up which will add to the already rich mineral deposits of our State, and to the development of her resources.

HENRY G. ROTHWELL, C. E., M. E.

Mr. Forster.— Do I understand that the writer of that paper claims Mr. Craig to be the original discoverer of these sandstones of the Upper Peninsula? I don't see how in any sense he can claim to be the *discoverer*. For more than forty years I have looked on these same stones. We old men have seen these things with our own eyes, and they have been there for centuries. They only became available when a market was opened for stone of that kind.

BEHAVIOR OF WOOD UNDER REPEATED AND VARYING STRESS.

It is a fact long since noted that a piece of metal subjected to a varying or oft-repeated stress will finally yield at a point less than that found for the breaking stress, had the latter been obtained in the usual way. That is, a piece tested for the breaking load is strained simply once until it yields. If, however, the highest stress is not quite enough to break the piece the first time, it probably will do so with a few repetitions. If the stress is still further decreased, the number of repetitions necessary to produce rupture rapidly increases, until when it falls to the neighborhood of the elastic limit, the number becomes very great, soon reaching a number practically infinite.

The problem is still further complicated, 1. By the way in which the stress is made to vary; 2. By the time during which it acts; 3. By the time allowed between the repetitions.

The stress may vary in the following ways: 1. From a fixed minimum to a variable maximum; 2. From a variable minimum to a fixed maximum.

The above minimum forces may be either positive, negative, or zero. That is, the stresses may vary from high tension to a lower tension, from tension to zero, and from tension to compression, and *vice versa*.

The time of action may vary as follows: 1. Time variation in the act of applying the stress; 2. Time variation in the act of re-

moving the stress; 3. Time variation in the duration of the stress at its maximum or minimum value.

Other minor variations might be mentioned, but the above are the most important. There is no general law involving all these variable elements. The nearest approach to it is known as Wöhler's law, which may be expressed by a formula due to Launhardt, as follows: —

$$M = u\left(1 + \left(\frac{T-u}{u}\right)\frac{L}{M}\right)$$

where u is the maximum stress which may be safely applied an indefinite number of times, the range being from zero to u.

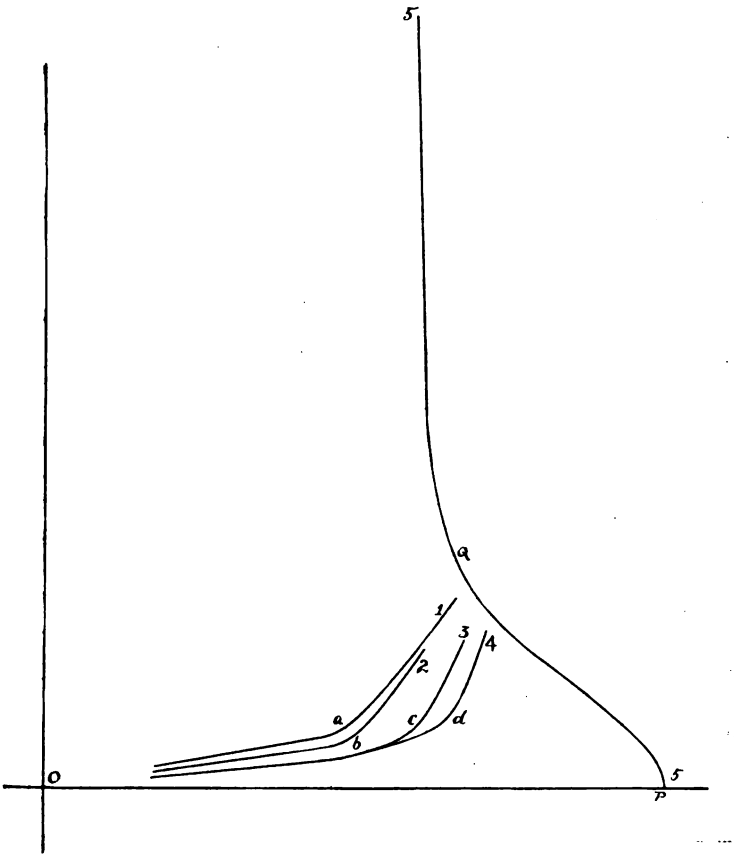
M is the safe upper stress for an indefinite number of applications, the range being from L to M. T is the breaking strength as usually found. In this formula the time elements and number of repetitions are not involved.

Such in general is the nature of the phenomenon usually known as *fatigue*. Metals seem to have been far more carefully examined for this phenomenon than wood. This is but natural, due to the greater use of metals for constructions subjected to varying stresses. The behavior of wood under such stresses is not, however, without interest, and as a contribution in this direction, the following account of some preliminary experiments is submitted: They were made during the summer of 1890 under the author's direction, by Mr. Chas. Ferris, then a senior student at the Agricultural College.

The machine used was an ordinary Fairbanks scale arranged to weigh the reaction arising from the application of the stress. The latter was applied by means of a screw bearing upon an iron shoe, the latter in turn resting upon a wooden shoe to prevent injury to the piece under test. The pieces were all of the same size, one inch square, of well-seasoned white pine, and so cut that the annual layers were parallel to one side. All tests were made with the annual layers in a vertical position. All pieces were supported on roller supports one foot apart, and were loaded in the middle.

It was desired to load them with a certain variable fraction of the breaking load, the number of applications necessary to produce rupture being the corresponding quantity to be observed. An attempt was first made to use as the breaking load of a piece, the mean of the breaking loads of a number of pieces situated contig-

uous in the plank to the piece in question, and apparently homogeneous with it in structure. The results were so irregular, however, as to show that nothing could be learned in this way. An attempt was next made to find some stress which should be in some way proportional to, or representative of, the strength of the piece. It was thought that the stress at the elastic limit might perhaps afford some such starting point; the idea being that this might be obtained without seriously injuring the piece, which could then be tested under loads higher than this by certain known per cents.



The apparatus used was not convenient for making diagrams of the stress and strain, and the length of time necessary for an examination for permanent strain rendered some other method necessary.

This was finally accomplished by using the *time* necessary for the strain to increase by a given small amount, under constant load.

The *modus operandi* was as follows: —

Weights would be placed on the scale beam corresponding to a certain load. The screw would then be turned down, straining the piece, until the stress developed would equal the load indicated. At this point the scale beam would rise. The screw would be so manipulated that the outer end of the scale beam would just touch the upper stop. If under this stress the piece of wood slowly yields, it will be manifested by a fall of the scale beam, which will be more or less rapid as the yielding of the wood is more or less rapid. The ratios were such that a movement of about one inch in the end of the scale beam corresponded to .01 inch distortion of the wood. The time needed for this amount of distortion was noted under the various stresses applied. The reciprocal of this time was the corresponding velocity of yielding. The results found in this way for four pieces are shown in the diagrams 1, 2, 3, 4. The horizontal distances represent stresses, the vertical distances being the corresponding velocity of yielding.

At *a*, *b*, *c*, *d*, a sudden change is seen in the rate of change of the velocity, resulting in its rapid increase, and indicating a point probably not very far removed from the elastic limit, though perhaps somewhat above it. Even if the latter were the case, it was thought to make no difference for the purpose in view so long as the stress was proportional to that at the true elastic limit, or in any constant way representative of the strength of the piece.

With this stress as a starting point determined individually for each piece, a number of tests were made, the means of which are given in the following table: —

Load at Elastic Limit.	Per cent added.	Load.	No. of Applications.	Time.
385	0	385	*a*	½ Min.
385	5	405	23	"
380	10	420	4.6	"
520	15	600	3.7	"

The number a is not known, but is greater than four or five hundred. No pieces were broken with the load at elastic limit, though several were tried.

A further set of four pieces was carefully selected and tested, the results being plotted in diagram 5. The horizontal distances represent stresses, and the vertical distances the corresponding number of repetitions necessary for rupture. At $O\ P$ representing 650 lbs., the number is zero, the piece breaking on the first trial. Below the elastic limit, or at about 450 lbs., it is practically infinite, but rapidly decreases as that point is passed, showing the great effect on the allowable number of repetitions, of a slight change in the stress, or what would amount to the same thing, of a slight change in dimension.

GENERAL CONCLUSIONS.

It will be noted that the pieces were tested for cross breaking only. The duration of the load for one application was usually one half minute, the interval of rest being the same. During the rest, the whole load was removed. In consequence, the stress was from 0 to tension for the under fibers of the stick, and from 0 to compression for the upper fibers. The number of experiments was too limited for any very general deductions, but so far as they go, we may seem to be warranted in the following: —

1. When wooden beams are subjected to cross-breaking under periodic stresses varying from 0 to a maximum, the safe maximum for an indefinite number of repetitions is about the stress corresponding to the elastic limit.

2. If the stress is carried beyond this point, the safe number of repetitions rapidly decreases, reaching a comparatively small number at 5 to 10 per cent increase.

W. F. DURAND.

A NEW FORM OF CONTOUR CALIPER.

THE objects sought which led to the devising of this instrument were as follows: —

1. The possibility of telling whether or not the contour or cross section of a pin, axle, or spindle is circular.

2. If not circular, the possibility of finding where it departs from the true or circular outline.

As a necessary consequence of 2, comes the possibility of making an actual map or diagram of the cross section in question.

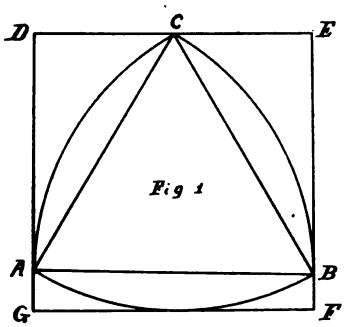


Fig 1

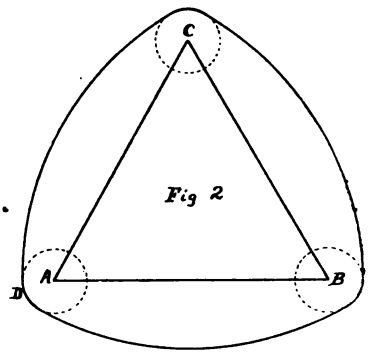


Fig 2

The ordinary or two-point caliper fails in both particulars mentioned.

1. It fails as a tester of the circular or non-circular character of a contour, because it does not discriminate between the circle and other figures of constant breadth. These latter figures in general constitute an interesting class of geometrical forms, of which a few examples may be noted.

In Fig. 1, let *A B C* be an equilateral triangle. With each apex as a center, strike an arc with radius equal to a side. The curvilinear figure will result. A little thought will show that this figure has a constant breadth equal to *A B* in all directions, and that with a two-point caliper as the measurer of this breadth, it could not be distinguished from a circle of diameter *A B*.

In Fig. 2, let *A B C*, as before, be an equilateral triangle. With each apex as center, strike a small circle with radius *A D*. Then with each apex as a center, strike arcs tangent to these small circles. The curvilinear figure will result. This may be readily seen to have the same properties as the preceding.

In Fig. 3, let *A B C D E* be a regular pentagon. With each apex as center and a radius equal to the distance to the apex nearest opposite, strike arcs. The curvilinear figure will result, which may easily be seen to have the properties of those preceding.

Any regular polygon of an odd number of sides may thus be made to serve as the basis of a figure of constant breadth, and by modifying the sharp corners by supplementary arcs of smaller radius, an infinite number of such figures may be formed from each polygon as a base.

Returning to Fig. 1, let *D E F G* be a square circumscribed about *A B C*, the length of side being equal to *A B*. A little thought will show that the curvilinear figure *A B C* will turn within *D E F G*, smoothly and without looseness or lost motion. It will always have contact at four points, and so far as turning without looseness is concerned, the pair might constitute a plug gauge and its mate.

The three-sided contour with rounded corners (Fig. 2) will also fit perfectly within a square. The five-sided figure, it may be seen, will fit and turn with a sextuple contact within a regular hexagon. In general, these figures will fit and turn smoothly and with constant contact within a regular polygon of a number of sides greater by one than themselves. If then a plug gauge and its mate, both supposed to be perfectly circular, should happen to have these forms, they would still fit with perfect nicety, and no ordinary test would detect the difference. The occurrence of such forms in anything like perfection is not, of course, at all likely in the usual operation of shop-work processes, though the three-sided form with rounded corners is frequently met with as the shape of a hole bored by a flat drill.

We thus see that the two-point caliper does not enable us to state that a contour which has a constant breadth is also circular.

2. In case the indications of the two-point caliper do show a non-uniform breadth, we are not thereby enabled to locate the error relative to a true circular form. In Fig. 4, for example, let the true contour be as indicated by the full line. The caliper being

used across the diameter *A B* will indicate a greater breadth than at any other point, but we do not thereby know whether the excess is at *A* or *B* or both, or if it were the latter, how much of it lies at *A* and how much at *B*. In other words, we are not enabled to make any local correction looking toward the production of a perfectly circular contour.

Let us now leave the two-point caliper, and attack the problem of devising an instrument which shall fulfill the requirements stated at the head of the paper.

Such an instrument, in order to discriminate between the circle and the general figure of constant breadth, must involve as its fundamental principle or mode of action, some property which the circle possesses to the exclusion of all other figures of constant

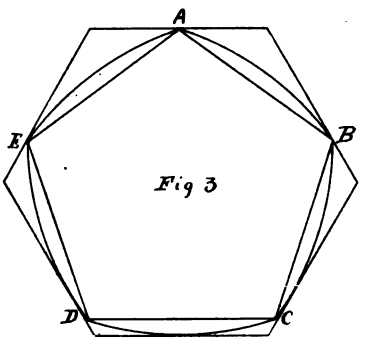


Fig 3

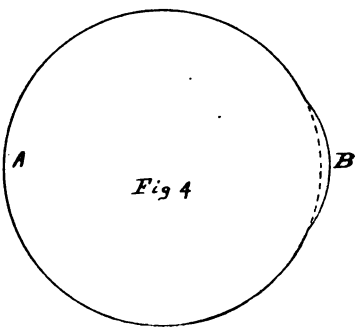


Fig 4

breadth. In order furthermore to make a map of the contour, there must be the possibility of locating its various points relative to some fixed point, preferably in its own plane.

The peculiar property of the circle made use of, was this: Through three points one circle and but one can be passed. In other words, three points which simultaneously touch it in one position will simultaneously touch it in all other positions, and if this is not fulfilled, the contour is not circular. Thus far we have a simple qualitative test. In order to show how it may be made quantitative and the contour thus mapped, we had best proceed to the description of the actual instrument and the method of its use.

P R (Fig. 5) is a metal ring supporting three composition nuts *L M N*. In these work three pointed micrometer screws, *A B C*, with reading heads *D E F*. The screws have twenty threads per

inch, and the heads have one hundred divisions. They are read from the fixed indexes *G H I*, so set as to compensate for the principal screw error. The reading is to one two-thousandth of an inch, and tenths of this may be estimated within a probable error of one tenth either way. The screws are adjusted so that their center lines shall all be in one plane parallel to the lower face of the ring. These center lines must also pass, if produced, through the same point *O*. This need not be the center of the ring, though

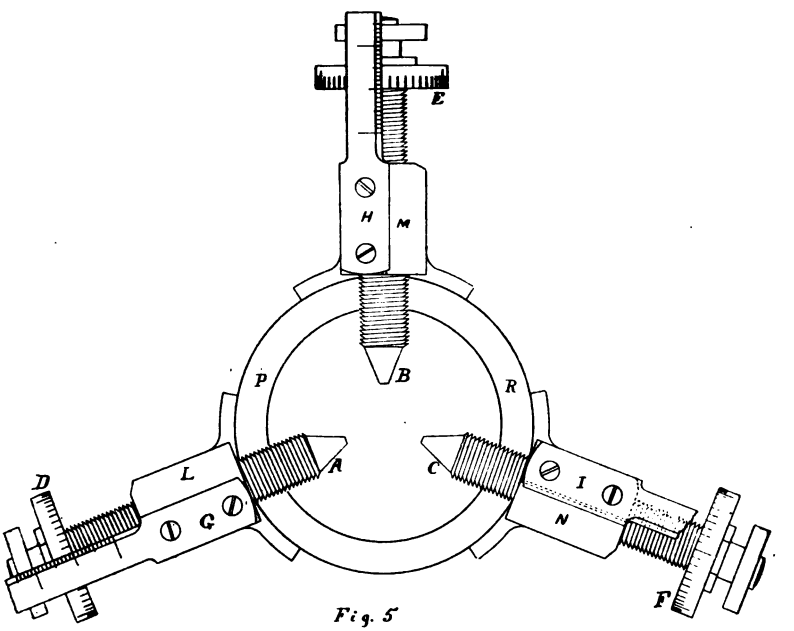


Fig. 5

it is convenient to have it so approximately. The graduations are so adjusted as to read from this point, which then serves as a virtual center or origin for all measurements. The angular openings *A B* and *B C* are each $\frac{5}{16}$ of the circumference, while *A C* is of course $\frac{6}{16}$, or 135°.

Suppose now a piece of metal placed between the points of the screws and held by appropriate adjustments with its axis at right angles to the plane of the ring. Next bring the points to bear on the surface, and so manipulate them that each shall have the same reading. The three points of contact are then equidistant from the

virtual center within, and this point of the metal under measurement will remain as the fixed origin for further operations. As a mere test for circularity, the piece may be rotated between the points. If the motion is firm and smooth, the contour is circular within the limit of sensitiveness of this test. This, however, is not the most delicate test, as will appear later.

To map the contour, proceed as follows: Suppose the piece in position, the three heads having the same reading. Place this reading at the top of three columns marked *a b c*, as in the following table. Place the same readings under *b* and *c* in the second line. Then back off *a* any convenient distance, in order to free the piece for easy rotation. Rotate it counter clock-wise through $\frac{5}{16}$ of a revolution, that is, until the point which was under *a* now comes under *b*, and that under *b* comes under *c*. These two points are

a	*b*	*c*
.8761	.8761	.8761
.8758	.8761	.8761
.8762	.8758	.8761
.8760	.8762	.8758
.8756	.8760	.8762

each distant .8761 from the center, and in their new position they come into contact with points having that reading, and therefore heading for the same point within, which before was the virtual center. Now bring down *a*, and suppose a slight hollow, making the reading .8758. Enter this in the second line, thus completing the second series of readings.

Next carry the .8758 of *a* second line to column *b* third line, and the .8761 of *b* second line to *c* third line, and adjust screws *b* and *c* to correspond to these readings. Then rotate as before, after having slacked up *a*. By this transfer of the readings of *a* and *b* second line to *b* and *c* third line, and the corresponding adjustment of the screws, it may be seen that the two points which gave the readings in the second line, find in their positions for the third line micrometer screws having the same readings. This continual transfer of readings and the corresponding adjustment of the screws, result in a constant preservation of the virtual center referred to above. With every line of readings, *a* gives a new point. After sixteen lines, the original points are returned to, and the measurement is complete.

Column *a* then gives the distances of sixteen equidistantly spaced points from the virtual center within. The order of the

points in the column does not correspond to consecutive order around the circumference, but the latter is readily discovered. Starting with any point as center, and laying off sixteen lines angularly equidistant, we may readily plot the contour to any desired scale. It is usually convenient to use two scales, one representing a circle corresponding approximately to the contour, and magnified a few times. The second representing the error of the

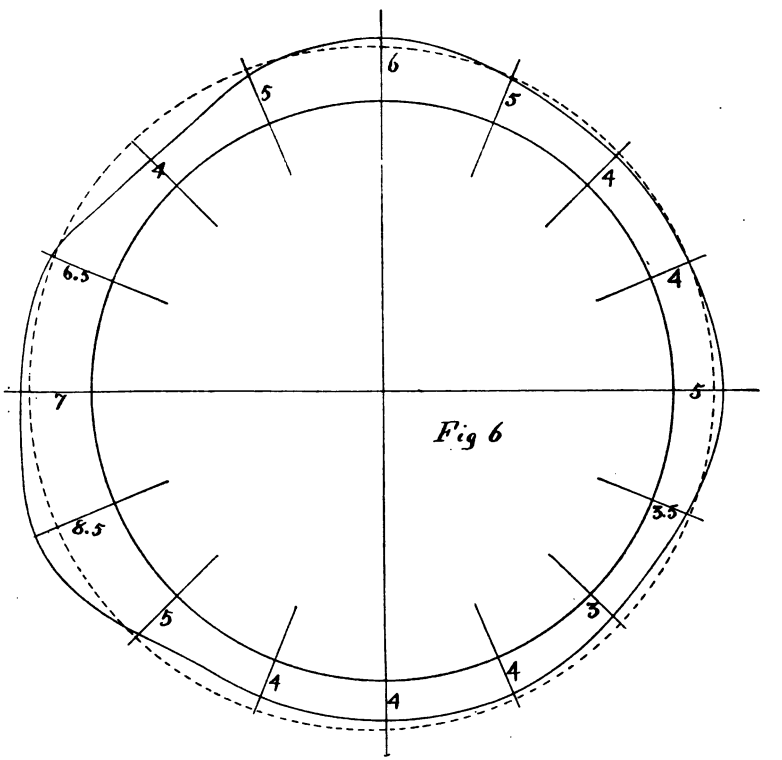


Fig 6

contour relative to this circle, and magnified several hundred times.

Fig. 6 represents an actual contour taken from the feed rod of a Brown & Sharpe Universal Milling Machine. The piece had been apparently finished by grinding, and probably represents about the best results attainable by ordinary machine-shop processes, when no special effort is made to obtain a circular contour.

The full circle is the original datum circle, and represents a circle $\frac{7}{8}$ inch in diameter. The scale to which the errors rela-

tive to this circle were represented, is nearly two hundred times the scale of the circle. The numbers represent the errors in ten thousandths of an inch. This graphic representation enables us to draw a second circle represented by the dotted line which corresponds most nearly to the contour.

The various diameters which a two-point caliper should indicate, are also readily found, and the contour can be tested in this way. The contour of Fig. 6 was thus tried, and the agreement was well within the limit of relative accuracy of the two instruments.

SOURCES OF ERROR.

In the adjustment of the instrument there are three chief sources of error, 1. The inclination of the axis of the screws to the plane parallel to the lower face of the ring; 2. The impossibility of making the three axial lines pass exactly through one point; 3. The index or initial error in the reading of the micrometer heads. Fortunately, these errors and their combination may be rendered entirely inappreciable in comparison with the necessary errors of manipulation.

Without entering into details, it may be said that the necessary adjustments are effected by the aid of a compound microscope and filar micrometer, making possible readings to the one fifty thousandth inch with fair certainty. The errors of manipulation arise chiefly from the varying pressure exerted at the point of contact. To render this constant, several well-known devices are available. With practice and care, this error may be made very small. As the instrument now stands, it seems that the instrumental error is about equal to the uncertainty of the reading, or that on the whole the reading may be in error one five thousandth either way. With larger heads and finer pitch screws, these errors could be considerably reduced.

W. F. DURAND.

Mail

THE ERECTION OF GRAND RIVER BRIDGE.

GRAND RIVER BRIDGE is on the Canada Division of the Michigan Central Railroad. It is a deck bridge consisting of four spans of about 155 feet, with iron trusses and stone piers and abutments. The piers were built long enough for a second track, but the abutments were not.

The superstructure was designed for lighter engines and trains than are even now being run over it, and while it is not considered unsafe, it is thought probable that further increase in the weight of trains will ultimately necessitate its removal. Therefore, when two spans were needed for a bridge on another division having much less traffic and lighter engines, it was thought best to take the superstructures of two spans from Grand River Bridge, and replace them by two new and heavier ones.

In order to avoid delaying trains, it was decided to erect the two new spans on one side, and then pull the old ones out and put the new ones in their place. The material for the new spans and the falsework was unloaded on the bank at the east end of the bridge. A track was then built down the bank to the east abutment, falsework put in place for the two spans, and the track extended across it. Material for the new spans was loaded on a strong lorry, and run on this track down the bank and out on the falsework to a traveler which was used for hoisting it into position. The second span from the east shore was erected first, and ties and bond timbers put on. Temporary extensions were built on the upper ends of the piers and east abutment, long enough to support the old spans when pulled out far enough to permit the new ones to stand in their final position, and to provide room for the crabs used in moving the spans. The ends of the new span rested on the masonry. Rollers three inches in diameter and eighteen inches long were then placed under the ends of the old and new spans. Three flat iron bars four inches wide and three fourths of an inch thick were used for each track for the rollers.

When everything else was ready, the track rails at the ends of the spans were taken up, and the old span pulled to one side by means of crabs and ropes one and one half inches in diameter, running through double blocks. The blocks were then detached from it, and fastened to the new span, which was then pulled into the position formerly occupied by the old one, and the rails laid on it. We had very little trouble with moving either the old or the new span; care had to be taken to keep them from moving longitudinally, as there was very little room between their pedestals and those of the adjacent spans, but by moving both ends alike and keeping the rollers parallel with the trusses, movement in this direction was avoided. The last train over the old span passed at 9:18, and the new one was ready to cross at 10:50, one hour and thirty-two minutes later. Of this time, thirty-eight minutes were taken to lay the rails after the new span was in position.

On the other span, all the rails except the four end ones were laid before it was moved. As the abutment at the east end of this other span was not built for two tracks, it was necessary to extend it to carry one pedestal of the new trusses. The others rested on the masonry. This extension was made with framed bents resting on timber blocking. The new span was built with one truss — the one with one pedestal on these bents — heavy enough for the center truss of a double track bridge, and as Michigan Central bridges are now built to carry very heavy trains, and have an exceptionally heavy floor besides, the load on the bents was about sixty-five tons, which was certain to settle the bents in the not very hard ground under them. Consequently the track was made a little higher on the bents than on the masonry, and jacks were placed under it, to raise it in case it settled more than was expected.

The bents did settle so that the track on them was a little lower than that on the masonry, but we managed to pull the truss on the masonry without using the jacks, after a delay of twenty-five or thirty minutes. The rest of the work on this span was done very quickly, the total time taken being one hour and six minutes The first train crossed the new span seven minutes later — one hour and thirteen minutes after the last one crossed the old span.

After the new spans were in position, their ends were lifted, the rollers taken out, and the wall plates and expansion rollers put in place. The falsework and traveler used in erecting the new spans

were moved so as to be used in taking down the old ones. The iron of the old spans was lowered onto a flat boat, taken ashore, and hauled up the bank by teams to where it could be loaded on the cars. In moving the spans, we had five men on each crab, and four handling rollers at each end, making eighteen in all, besides the foreman and myself, and about fifteen section men to take up and relay the rails.

B. DOUGLAS.

ROADS.

Gentlemen of the Michigan Engineering Society: —

I EXPECT to say something on the subject of roads this evening. I need not refer, except in the briefest terms, to the fact that the public press, everywhere, is full of the subject of road-making. This is the case in Michigan. It is a matter which may profitably occupy our attention for a little while this evening, I think. I believe it will be of interest to see how the general interest in this matter came about; what is likely to be accomplished; and, in a general way, what are the forces at work, as well as what they are likely to accomplish in the future.

But to speak of the subject from the points of view which I have somewhat hastily indicated: The interest in better roads came largely from the American wheelmen. The bicycle needs a good road to run on; and while we may take that as a prominent fact in the case, I think it is not the real cause of the present widespread interest in this matter. The American wheelmen have taken a great deal of interest in this subject; and here lies a little book, called "Public Highways," which is published for free distribution, which you can readily obtain, and from which one may get a great deal of information. It contains Clemens Herschel's celebrated paper on the subject of road-making, says something about pavements, and presents a copy of the legislative enactment prepared by wheelmen for the use of committees in the various States, and which was introduced two years ago into the Michigan Legislature. It will be found, when the history of this movement is studied, that Mr. J. E. Beal, proprietor and editor of the Ann Arbor *Courier*, has taken a very prominent and useful part in dis-

tributing extensively, through the rural papers, matter of interest to all, bearing on this subject, and so disseminating very widely, and where it is most needed, facts and information. I am sure that every one would like to see better roads.

Back of all this, however, there are certain other considerations. The business men have found out that good roads are of great benefit to them. This refers to the hardware trade, grocers, dealers in tools, dry goods, and all staples. We now have the matter reduced to a question of business, and I feel sure something will be done. The carriage-makers want to sell more of their goods; and if there are good roads and much driving, they will sell more. But still more important than this is the fact that good roads are becoming recognized as excellent feeders for the railroads. The railroad men have found this out. Be sure they will find means of exerting an influence in favor of better roads. It is well understood that good roads advance the value of real estate. When real estate men desire to put a piece of land on the market, the first thing that is done is to connect that land with a trade center; in other words, with other more valuable land, by improved means of communication, which means of communication is more commonly a good road than anything else. In the same manner, farms are raised in value by being made accessible by first-class roads. They are also raised in value by having the farm expenses reduced. Let the farmer recall that part of his expenses caused by travel on highways, and let him consider what would be the fact were this divided by almost any number from two to ten. Let him be assured that these numbers are well within the truth, for they are.

Again: There has been a change in the way in which we live. All are knowing to it. Some notice one thing, some others. One change is this: We live more and more off of the cities, villages, and stores, less and less off of home-made products. Many of those who sit here will remember when nearly everything was made at home. I have a very distinct recollection of when shoes were made in the country, at the village and farm houses. Frequently there would be seen on the farm a small building for a shoe shop, standing a short distance from the house, or it was attached to the house itself. These were the shoe manufactories of those days,— the places where the store shoes were made. All our clothing was cut and made in our homes by tailors who went from house to house. The shoe business is a good business to-day,— so is the manufact-

ure of clothing. I simply cite you a couple of instances of the past and present habits of the people. These things are no longer made at home. This is an age of combination, concentration, and transportation. Hence there *must* be lines of communication of all sorts. And here, I think, lies the philosophy of the movement which is felt at the present time, for better roads. Common roads enter more and more into the system of communication. They must take their place and part in the common movement of the age, noted above, — concentration and combination. There are now great manufactories, great centers of storage, great trade centers, great supply points. As a consequence, there must be —

1. A great system of gathering.
2. A great system of distributing.

The common road is the last detail in the extension of this system. It is feeling at last the influence of its place in the plan. Railroads and canals have been built. Waterways have been improved. Telegraph lines have been put up, and the means of verbal communication vastly improved and extended. As a consequence of the great changes already taken place, it is found, at the last, that the common road has a place in this great system of vital trade circulation, and that it must be put on a par with the rest. The common road is the weakest improvement we have. But now it is found that by improved roads the tradesmen and other business men are to be benefited; the railroads (and in consequence, their owners), better fed; that farms and other real estate, are to be worth more; that trade is to be bettered; and that the common road is really a link (and a wretchedly poor link, too, as will appear further on) in the great unifying system of transportation. I have no doubt it will be made far better than we have ever been accustomed to see it. With these interests at the bottom, I cannot perceive any long delay in the coming of good highways.

We are accustomed to hear much complaint about our roads. There are better roads elsewhere,— next town, State, nation, England, Europe,— somewhere else. Now this same complaint will be found running its course in any of these places, if one visits them. It is certainly so in England. We are not to mind this disease. It may not be even a symptom of anything but a chronic tendency to growl. Take a business view of the situation. What are the facts? How can things be bettered? The main facts are

plain enough, and well enough understood. Good roads *pay* in every way. American roads are the commonly cited illustration of what not to do in all countries where they are well known. The more local the plan of taxation and administration, the worse the roads, till in the South they are but wagon trails. The trade of a town or market increases as the square of the distance to which goods, and from which produce, can be sent at a given price for transportation. It costs about the same to carry a bushel of wheat (sixty pounds) a mile on our roads as it does to carry a ton a mile on a railroad. "West of Lake Michigan it rarely pays to grow wheat more than twenty miles from railroad or water transporta tion." (See United States Census 1880.) The profit on wheat raising, then, is lost on the road between the field where it is raised and the nearest market situated on a transportation line. Wheat is only an illustration. All farm produce must pay the same tribute to bad roads. These are a few of the well-known main facts above referred to. The last of them are made equally plain by reference to standard works on road-making. Rankine's "Civil Engineering," p. 624, shows that on a level road it requires a pull to move a load, of from one seventh of the load on soft sand and gravel to only about one seventieth on stone pavement. Gen. Gillmore in his experiments found a variation from one eleventh on a common earth road in fair condition to only one one-hundred and eightieth on best smooth stone tracks. That is, a horse on one kind of road may be able to pull the load of ten on another kind of road.

But we cannot look quite so high. The comparison with the best broken-stone roads shows that a horse can there pull the load of seven horses on a poor dirt road; in muddy times, no doubt, much more than this. Putting this in another form, and using a near-by illustration, the roads in five townships in Washtenaw county, Mich. (a rich agricultural county), in 1889 cost from $18 to $32 per mile, and an average of about $25 per mile. Were these all broken stone roads, well constructed, regardless of classification and say of seven times their present value (and seven is not an excessive number), evidently these townships could spend seven times $25 per mile, or $175 per mile, and still be at no loss. But $169 per mile is the cost of a main road in England, while ordinary roads (as the great bulk of these would be), cost but $58.32 per mile. But these roads are not built of broken stone. Let the most needed few miles be first taken, and the odd $75 taken for

maintenance, leaving the $100 for interest, and it will pay for the use of $2500 per mile to be rapidly expended in making that few miles worth seven times what it is now. But this kind of testimony is really argument, and of an unsafe kind. It can serve but to show us the well-known wastefulness of our present methods. Enough of the facts for now.

What will aid to make our roads better?

Inform those interested what their interests are, the farmer, the tradesman, the railroad man, the fruit grower, the real estate man, and all the rest. Once the people realize the situation, they will find ways to better things.

Another thing: Some powerful interest, like some line of manufactures, the grain dealers, or the railroads, will find it for their interest to secure legislation compelling road improvement.

Still another: The whole matter may be taken into consideration, and the situation studied by our legislative bodies, and measures be adopted meeting the real wants and interests of all concerned.

No doubt all of these forces are at work now in various localities or States.

Whatever changes in our present methods are proposed, to have a value to us they must be based on the existing state of facts, not some ideal condition, or some other circumstances. They must fit us and our surroundings. We now have from fifty to seventy-five miles of road, of various degrees of badness, in every township in the more thickly-settled portions of our State. This is not to be abandoned and new roads built. It is to be put in order and improved. Some of it can be profitably abandoned and rebuilt, no doubt, but this is the exception. We also have a system of taxation which is not to be abandoned, but obeyed, improved, and used for raising funds for these improved roads. So it appears at once that whatever changes we may make, there must still be —

1. Ways and means provided — taxation.

2. Expending the means provided — administration — also including the reports and returns.

I believe our first change should be to a system. The public roads should be in the charge of the best engineers that can be had, and get men who will devote their entire time to it. The second change should be the adoption of a classification of our roads. The third, in the manner of raising the money — the taxation

Those who have special privileges in the roads should pay for them. There may be found some unused sources of income.

We can improve even under our present circumstances. Substitute continuous repairs for our annual "fixing." Place a few men and a team on a district large enough to keep them busy all the time. Have them keep the waterways open and in repair, mend bad spots, pick off loose stones, take out large stones, fill ruts, cut weeds, and the like.

To prepare for changes, and to make them intelligently and properly,—

1. Study the experiences of others.
2. Study our own situation.
3. Plan the changes, if any, afterwards. Whatever changes are suggested must show a reasonable chance of being profitable.

So far as new legislation is concerned, I have little to say. Changes in that line should be based on the same studies and bear the same test as are above noted. I believe, however, we should make our paupers and criminals useful to us instead of maintaining so many of them in idleness or worse, as is now done. They should keep us in roads, as far as their labor will do it. But I mentioned this matter more particularly to you in 1887. (See proceedings for that year, page 111.)

As engineers, we must study the situation. The people desire that their investment shall pay. We must meet that condition — the prime one in modern engineering. Much has already been done to gather facts and information. Here is a book in the form of a pamphlet, by J. W. Jenks, Ph. D., entitled "Road Legislation for the American State," to be had of A. C. McClurg & Co. of Chicago, for 75 cents. This book contains the road legislation of every State in our Union, also an account of the road laws of France (where the best of roads are to be found) and of other countries. It tells much concerning the systems of administration in many places, with a valuable dissertation upon taxation for road purposes.

There is every evidence that this subject is receiving a great deal of attention now; it is coming before the people constantly. In some of the States, colleges are offering special courses in road-making, and holding out inducements of a very special character for young men to come and educate themselves for road engineers. As citizens of Michigan, you doubtless will be pleased to be re-

minded that instruction on the subject of road-making has always been given at our State University for at least a quarter of a century, and has there been considered as a necessary part of the systematic course of training for all civil engineers. The work in the University covers the field, and I have no doubt, though not as familiar with the work there, that the same is true of our Agricultural College here near Lansing.

Now I am well aware that I have touched lightly and briefly on this subject. There are many points and principles upon which I have said nothing. Furthermore, I do not desire to enter into details. You who want reading matter to begin your studies and investigations with, will readily obtain it from the League of American Wheelmen. J. B. DAVIS.

Mr. Steele. — Mr. President, I thank you for the presentation of this subject this evening. I know that practical experience in road-making is a good teacher, and unmaking them will teach us more. There is one element that destroys our roads more than any other, that is, water. Take for instance one case. I live five miles from Traverse City, at a point which might be called summit, over 300 feet above the bay. We cut this part of the road down several feet, and the rains came soon after; and when the heavy loaded wagons came through, at certain places, little holes were started, and more water settled in them, and they gradually got deeper and larger, until they would take in the whole width of the wagon. Now if a man could have been there when those small holes started, and given them some attention, this bad condition of the roads would not have been. Let us have a system of watchfulness over our roads. Employ men for that purpose. They can go along with simple tools, and repair at the right time. Another point I would like to hear discussed. Why would it not be practical to lay a large tile in the middle of the road with lateral branches at lowest points? Then the water that falls there would be taken out quickly, and the road would be left in good order. I think that as a society we ought to take some steps. The roads ought to be in the hands of competent engineers, but of course just as soon as we advance this, the idea will go out, "Oh yes; they want a job." What we need in the State of Michigan just now is a most thorough discussion of this subject. Get the press interested, and you will find that we will soon reap the fruit.

J. H. Forster. — Now it does not seem to be the want of any information, and we should insist on having better roads. I have been pathmaster, but I never was pathmaster more than one year. I don't suppose I let them fool around and every man have his own way enough to suit them. This whole thing is wrong from top to bottom, and I do say something must be done. Whether it will be met by the legislature or some other power, I don't know.

A. J. Teed. — I have given this subject a good deal of thought. It is useless to try to improve our roads by patching up our present road system. If we would have the best roads for the least money, we must make a radical change in our road laws. I do not agree with our President that all improvements in roads must be made on the present highways as they are now located. In the newer parts of this State there are many roads yet to be laid out; in the older parts of the State highways are being continually changed, so that much may be done in the way of better location. When a railroad or a lumberman's logging road is built, it is located on the best ground; but when a public highway is laid out, you cannot convince the settlers that it belongs anywhere except on the section lines.

The great trouble in our road system is that it is too local. Roads are laid out and worked to accommodate the immediate wants of the adjacent settlers, with little reference to the needs of the traveling public generally, or to future requirements. A second defect in our road laws is that the Highway Commissioners are not experienced road builders, and their tenure of office is too short to enable them to acquire this experience.

A third defect in our road system is the want of concert of action between the local road districts of a township and between the different townships of a county. These three defects might in great measure be remedied by putting all the principal highways and all the highway bridges of a county under the control of a commission of experienced road builders, one of whom should be a civil engineer. If the location and construction of the roads was under the supervision of experienced men, it would not matter so much how the tax was collected.

Mr. Hodgman. — The only way to have our roads properly improved is to keep agitating and educating. People do not, as a rule, realize the cost of bad roads. As a rule, it costs less to make good roads than it does to pay out nothing for making

them, and have bad roads. I have several times made estimates of the cost of bad roads, and placed them before the people of my vicinity; but keep it as low as you can, the aggregate is so large as to be received with incredulity and a shake of the head. For instance, the township of Climax has about 72 miles of road. On one of the best miles of this road a man once hauled 142 bushels and some odd pounds of wheat with two horses and a wagon at a single load. Eighty bushels per load can be hauled on that road the year round as an average. But take it the township through, and the wheat buyers tell me the loads do not average over 30 bushels. Suppose it were 40; then half the time spent in moving everything that is hauled over the roads is wasted, because there is not a mile of road in town but what can easily be made as good as the best mile in it now, or very nearly so. The amount of produce, etc., of all kinds hauled on these roads, amounts at a low estimate to the equivalent of 200,000 bushels of wheat. The distance hauled will easily average 5 miles. Now by hauling only 40 bushels instead of 80 per load, there is a dead loss of 2,500 trips,— time of men and teams,— besides the wear and tear which is so much greater than on good roads. If we call the distance hauled 5 miles or 10 miles for the round trip, then there is wasted enough to equal a trip with a loaded wagon half way around the earth and back again empty. If we call 15 miles an average day's work for a team on such roads, and figure the price of labor of man and team including all expenses at $3 per day, then it figures up that we are wasting $7,000 a year; that is, our bad roads are taxing us that much every year. If we had that in money to be applied economically on the roads, it would be but a very short time until every road in town would be as good as the best now in it. What is really wanted is a money tax to be laid out under the direction of competent roadmakers.

THE GRADIENTER.

At the Kalamazoo Convention of this Society, a paper was read on the gradienter, in which the author called special attention to an alleged fallacy in its construction, which was likely to lead to errors in its use. It was sharply discussed pro and con and withheld from publication by its author, until he could rewrite it to meet the arguments which were opposed to it. It was not returned in time for publication in the proceedings of that year, and went over till last year, when it was sent in and published without discussion in the "Annual" for 1890.

As I consider the gradienter an exceedingly valuable attachment to the transit for use under certain conditions and in certain places, I dislike to see any unnecessary discredit thrown upon it, and hence I enter an objection to the subject-matter of that paper of a different character from any presented at the time of its discussion. I will not repeat the Author's argument, only his conclusion, which is that "this erroneous principle always gives distances too small *except* [italics mine] *those determined with angles under about 3°*." To which I reply that the exception covers the entire range of the instrument under the conditions in which it is ever likely to be used. It is of no earthly consequence to anybody whether there is or is not an error in the instrument outside of that range. Let us consider a little the uses to which a gradienter is put. In my opinion its greatest value is for use on railroad location in an open country, where it is a most valuable assistant in selecting the position of the line to be located.

An adjustment of the instrument and a glance at the gradienter tells the locating engineer in feet per hundred just what kind of slope he has to contend with, and if it be in a mountainous region where a certain grade line has to be fitted to the ground, it tells him at a glance, without waiting for the leveler, where to find the ground to fit his grade line. I have found in work of this kind that the gradienter saved nearly, if not quite, half the time of the

party; in other words, that I could get nearly twice as much accomplished with it as I could without it, because of the saving in preliminary work by being able to locate the line in the right place the first time trying. When a locating party is costing the company $600 to $1,000 per month in the field, this is an important item. And yet the steepest line of this kind I ever had to run was on the west slope of the Wasatch Mountains, where we had for several miles a continuous rise of 3.8 feet per hundred.

A 3° range on the gradienter gives a 5¼ per cent grade, which is steeper than any ditch, canal, or railroad grade that I know of outside the rack railroads.

Another use of the gradienter is to measure distances; somewhat similar to stadia measures. When used for this purpose, a graduated rod — generally a leveling rod — is used with the transit. If the rod is one hundred feet from the instrument, one foot space on the rod is all that is used. Three degrees cover 5.24 feet. If the rod is 1,000 feet away, which is about as far as such measures are commonly taken, ten feet space on the rod is all that is required, if we use a foot in a hundred. Three degrees give a range of 52.4 feet, which is a longer rod than I ever knew a man to carry.

While on this subject, it may not be amiss to say that the vertical circle or arc may be used in place of the gradienter with only a little extra trouble. We have only to change degrees and minutes of arc into feet per hundred by use of the table of natural tangents. Thus if we wish to run a grade line of one foot in 100, we find in the table of tangents the corresponding angle to be 34½′. Or if we find the ground ahead of us to have a slope of 24′, we see by the table that it is seven feet in 1,000, or $\frac{7}{10}$ per cent. This may seem a simple thing to refer to. Other surveyors may be quicker to "catch on" to a point than I, but I had run transit with vertical circle and without gradienter on railroad lines a good while before I thought of this application of the table of natural tangents. In fact, it took me a long time to get rid of a feeling that somehow it took a different process to solve a triangle when it stood up, than when it lay down. F. HODGMAN.

A. J. Teed. — I have been using a gradienter for the last two years, and find it very convenient in leveling up and down hills and over logs. Where extreme accuracy is not required, by setting

the gradienter at some convenient angle, as one or two feet in a hundred, and then making the necessary correction in the rod reading, much time can be saved in moving the instrument. For convenience, the transit should be set over or near a station.

F. Hodgman. — I will add to what has been said, that I think the gentleman who wrote the paper on the "Fallacy in the Gradienter," started out with a false premise, which vitiated the entire argument. This is the way he states the premise: —

"The theory of this machine — or attachment to our transits — is *that the variation in the angle of elevation of the telescope, varies strictly with the number of revolutions of the tangent screw.* So far as the *sine*, the *chord*, the *arc*, and the *tangent* of an angle may be regarded as equal, the above law may be regarded as true."

But that is not the theory at all. In every description of the gradienter that I have seen, it is expressly stated to the contrary. For instance: Young & Sons, in their description of the gradienter, say, "The number of revolutions and parts of a revolution as indicated by graduations in the screw-head, measures the grade from the level, *not in terms of arc*, but in measures of base."

The gradienter does not measure angles in degrees and minutes, but measures a base in feet and hundredths, and does it correctly throughout its entire range. No engineer need to fear using it at any angle within its reach.

ENGINEERING FOR LUMBERMEN.

ENGINEERING for lumbermen, so far as its special features are concerned, is a growth almost entirely of the last ten years. Fifteen or twenty years ago the lumbermen of Northern Michigan had very little use for a surveyor. In fact, the less they saw of one, the happier they were. Land was cheap; timber was cheap; and no one wanted to know where his lines were, nearer than the land-looker could show him; and as for the engineer, they had no use for him. As timber increased in value, so increased the anxiety of the lumberman to get every tree that belonged to him; and he knew too well by experience, the consequences of taking a tree that he did not own; hence accurate land surveying has taken the place in the woods, of the guess-work methods of twenty years ago.

A dozen years ago the logs were mostly hauled on the snow over well-graded and finely-constructed sleigh roads, the laying out and construction of which, though well and neatly done, required no greater skill than was to be found in any well-regulated lumber camp.

That is all changed now; most of the timber to-day is hauled over logging railroads often from twenty-five to thirty miles in length.

In new counties also, around the mills, villages spring up. The lumberman's engineer, in connection with laying out a railroad and mill site, is often called upon to stake out a town. I have not unfrequently been required to survey land, run railroad lines, and stake out village lots, all in the same day, and with the same set of instruments.

THE EMPLOYER.

The engineer usually has very little to do with the proprietor of the timber. Sometimes he does not even see him. The man the engineer has to deal with is the general superintendent. This man is usually intelligent, well posted in his business, a good

judge of human nature, and withal a very pleasant man to deal with.

In all minor details, the engineer is generally left to the exercise of his own judgment. But the superintendent has a very definite idea of what he wishes to accomplish, and he can very quickly tell whether or not his engineer is equal to the emergency. It is useless for an inexperienced fraud to impose himself upon the superintendent of a lumbering firm. His inability will very soon be discovered, and he will be invited to move on to another job.

CHARACTER OF THE LUMBERMAN'S ENGINEER.

The lumberman's engineer must be a thoroughly competent land surveyor, always ready for any emergency, and must never make any mistakes. In railroad matters, the engineer must not only understand the principles of locating a railroad, but he must be well posted in the peculiar requirements of a logging railroad. He must know what grades and curves are admissible; how much it will be advisable to expend in grading his road; and how he can reach the timber so that it can be the most economically moved.

He has not only to consider the route as to the cheapest and best place to build the railroad, but he must also consider how the logs can be the most economically placed on the cars. It is not always the cheapest railroad to build that is the cheapest for the lumberman. The expense of getting the logs on the cars is often more than that of hauling. A difference of five cents per M. in skidding and loading will often pay for building a long piece of road.

I laid out a road for a Manistee lumberman last summer where a difference in cost of five cents per M. in getting the logs to the mill would amount to over $10,000. We had a choice of three routes, and the problem was not only to decide which of the three routes would take the logs most economically to the river, but as there would be a difference in the cost of driving the logs on the river and of hauling the supplies to the camps, according to which route was taken, this also had to be considered.

The pine lay in a belt two to three miles wide, and about eight miles long, parallel with the Manistee River, and about five to six miles distant. It was necessary to look over this whole tract of

country both with a view of determining the relative cost of building the road, and of hauling the supplies by the different routes. We solved the problem, but we were greatly facilitated in doing so by the stubbornness of a Dutchman who stoutly refused to allow us to build the railroad over his valuable piece of sand.

The lumberman's engineer must know many things not found in the books, and many things that he can learn only by experience; and that experience is too often learned at the expense of the lumberman.

KIND OF TOOLS NECESSARY.

In going to and from his work, the engineer has frequently to ride thirty or forty miles in a buggy over a rough road, and it is convenient not to be loaded down with any more tools than are absolutely necessary. For this purpose a light transit with level attachments and a good needle, is the best instrument; with this, one can do any kind of work required, and it is not convenient to be encumbered with two instruments. A 100-foot chain is the best for measuring. It is well to carry along a tape to be used when accuracy is required. As the assistants furnished are always inexperienced men, it is necessary to use a self-reading rod, which for the sake of portability should fold up to a length not greater than seven or eight feet, and be capable of being extended to twelve or sixteen feet.

About all the other tools absolutely required are a pocket compass, a hand level, a pocket set of drafting tools, a supply of profile paper, a little quinine, and a good supply of oil of tar. The last article is sometimes quite as necessary as the transit.

METHODS OF WORK.

In methods of work, engineering for lumbermen possesses these characteristics: *First*, That the work be rapidly done. No puttering or fussing over some ideal nicety can for a moment be tolerated. *Second*, While the work does not require extreme accuracy, the engineer, like Gillespie's needle, must never be very wrong. The work must be done on correct principles. A good needle line and chain measurement, if the method is correct, will never get the lumberman or his engineer into any trouble. The engineer must go fast and go right. Unlike farm lines, the lumberman makes no attempt to perpetuate his lines and corners after the timber is cut.

As soon as the timber is removed, the fire runs through the woods, and soon obliterates all traces of the survey. The government corners of course should be carefully perpetuated; but it is not worth while to spend much time on the interior corners. They can be better set when they are wanted, if they ever are.

In railroad building, I generally commence my work by taking a pocket compass, a hand level, one assistant with an ax, and look the country carefully over, blazing those places that seem to be the proper places for the railroad. When I have thus gained a general idea of the country, I run a random line where it appears to be the best ground, and take a level on it. And then in the evening, so as not to take the time of my assistants, I construct from the notes of my random lines, if the grades are satisfactory, a set of notes from which I can locate my line just where it is wanted, with no further calculations than can be made mentally in the field.

In running the random lines, I note all those places where the line must pass, and in locating run the curves with reference to these points.

For example: Suppose I have been running a 4° curve, and when I get around parallel with my next tangent, I find I am 10 or 20 feet to one side; instead of going back and re-running the curve, I note what change in the course of the tangent would be necessary to carry me through the next pass. I then lengthen or shorten my curve sufficient to make the requisite change in the next tangent, and go ahead. For this work I find a good set of traverse tables very convenient. After my line is located, I take my levels, and that is often the last I ever see of it.

Except in rare cases, no cross-section or calculation of earthworks is ever made. Nothing but the center line is staked out; of this I furnish the foreman of the camp a profile with the cuts and fills for each station marked on in figures, and the foreman or his grader works out the line with no further assistance from the engineer.

GRADES AND CURVES.

As to what grades and curves are admissible on a logging railroad, it is difficult to give accurate data, so much depends on the circumstances. The engineer must find out what kind of engine it is proposed to use, how much pine it will be necessary to haul in

a day, the total amount of pine to go over the road, and, lastly, the size of his proprietor's pocket-book; for frequently the lumberman does not think himself able to build such a road as the engineer might think the most economical.

As to curves, any curve on a steep up grade is very objectionable: and a sharp curve at the foot of a steep down grade should always be avoided. If a train gets to slipping down a steep grade with a sharp curve at the foot, it is very liable to jump the track. A 4° curve on the whole is a very good curve; it is not so sharp as to be objectionable, and is very easy to run. From that up to 8° or 10° will be allowable where there is not much grade. For a direct action engine, on the main line, I would never put in a curve sharper than 8° or 10°, and never sharper than 4° or 5°, unless the nature of the ground requires it. With a geared engine, when the ground requires it, a 16° curve can be worked over with perfect safety by running slow.

On a road where I did some work, an engineer put in a 16° curve at the foot of a long grade where it was desirable to run rapidly. The ground was level, and a 2° or 3° curve could have been laid as easily as the one he laid. More accidents have happened on that curve by engines and cars jumping the track, not to speak of loss of time in being obliged to slow up the train in going around the curve, than the time of the engineer was worth for a year.

In regard to grades, so much depends on the character of the engine used that no definite rules can be given. And yet it is often very desirable to know just what can be done in particular cases.

This can be answered best by giving a few examples of what has been actually done, and leave the engineer to draw his own conclusions in his particular case.

With regard to engines, the Shay geared engines will haul a greater load over a hill than any other form with which I am acquainted, but they are slow. I have seen one of these engines, about 12 tons, haul 2 to 3 cars up a 4 and 5-foot grade, and handle 6 to 8 cars down a 5-foot grade, with no accidents. This same engine has for the last 2 years been successfully working a train of 15 cars on a long down grade of $2\frac{2}{10}$ feet. They have never had any accidents since the track was properly ballasted, but I do not think it would succeed if the grade were over $2\frac{1}{2}$ feet.

Another of the geared engines of 7 tons pulled all the pine of a half section over a hill where the grades run from 6 to 9 feet in a 100; but it could not haul over one or two cars, and sometimes not that. When the track was wet, the down grades were not safe, and they had a good many accidents. One of these engines will do very good work switching over hills of 4 to 5 feet, but on the main line, when a full train is to be hauled, the grades should be less than 2 feet up and 2½ down.

On another road, where they use a 12-ton Porter engine, there is a grade of one foot with a 4° curve at the top; total raise, 20 feet. The regular train is 15 cars, but when the track is wet, the engine cannot make the top of the hill without taking a run of at least ½ mile. On this same road with a 14-ton Porter engine they can haul up a one-foot straight grade 30 cars when the track is dry, but will sometimes stick with 20 cars when the track is wet. But on a $1\frac{6}{10}$ straight grade this same engine makes 2 trips for 18 cars.

On another road a Boulehis engine, 22 tons, hauls 6 to 8 cars up 3-foot grades for its regular trains. I have seen a 19-ton Mogul engine haul 10 cars up a 2½-foot grade at the rate of 8 miles per hour, but this same engine in trying to come up a 4-foot grade with 3 cars slipped, and went to the bottom.

The best work of which I have any accurate data is being done on a road that I surveyed this summer. This road goes over a hill 150 feet high. The last 1,200 feet of the up grade is 3′ per 100. The first half of the down grade is 2′, and the last half is 3 feet per 100, with 2 16° curves. Over this hill a Shay geared engine of 30 tons on the drivers, with 3 10 x 10 cylinders, is daily drawing 15 cars of 2 to 3 M. feet each. This engine can draw 2 cars up 27 feet in 300.

These cases which I have cited are all extremes, and not to be recommended only when the necessity of the case requires it. My rule is to keep the track as near the surface of the ground as I can, for economy's sake; but I never put in any curves or grades that I do not know are perfectly safe without first consulting my employer. A. J. TEED.

Prof. Davis. — We are often told that the pine is fast disappearing, but there is a great deal of pine coming out yet, and there are a great many useful methods being used in getting out the pine. The result will be more science used in this field, not only for get-

ting out pine but other timber also. So it is not only a favor for us, but it is for the benefit of those who will come after, who will have much more to do than we.

Mr. Teed. — In regard to hand levels, I had occasion a few years ago to take the levels on a line about five miles long with a hand level; afterwards this same line was run over with a standard level, and I found that my hand levels were nowhere more than two feet out. It is my custom of late years when I come to a steep bank of a river or ravine, first to set a peg on the opposite bank with the standard level, and then level down and up the bank with the hand level. I generally come out within one-tenth. My level is one of Gurley's first make.

It is surprising how good work can be done with very poor tools, when occasion demands. On one occasion I had broken my level, and while it was being repaired, I took a common level vial obtained at a store, tied it to a stick, and attached this to my transit. It was not very sensitive, but I took my levels, taking short and equal fore and back sights, and when the road was graded, you could not tell the difference by the looks of it.

Prof. Davis. — In regard to what Mr. Teed has just said, I will say, I suppose all of us are familiar with similar experiences, where we have run our peg levels over certain lines, and have gone back and compared our elevations of the pegs both ways. Mr. Teed is certainly sound in using his bottle.

MAPS FOR THE USE OF ASSESSORS IN VILLAGES AND TOWNSHIPS.

To the President and Members of the Michigan Engineering Society: —

WHEN our genial Secretary, in his innocent way, invited me to "suggest a topic for discussion at our annual meeting," I little thought "it was loaded," or that I would be "hoist by my own petard," with an official order to prepare a paper on the subject so suggested. My idea was to receive rather than impart information.

Some experience in preparing maps and plats in connection with the decennial appraisements in the State of Ohio, and several terms as supervisor and city assessor in Michigan, have caused me to devote much time and no little thought to this subject. I trust it will be possible to so increase the general interest in it as to lead to some action by our Society through its legislative committee or otherwise, looking to enactments authorizing in each and every county a complete set of town and township plats suitable for assessment purposes. As this means work for the individual members of our Society as well as the fraternity generally, besides a great convenience and safeguard to every property owner in the State, there should be no opposition, but a united effort to gain the end sought.

My ideas are based largely on the Ohio laws and practice, although I do not commend the decennial appraisement system there in vogue. This fixes a value upon each parcel of land once in ten years, which value remains unchanged and unchangeable for the next decade, as inelastic as the law of the Medes and Persians. This is hardly adapted to the requirements of a new and rapidly-growing community, or, for that matter, an old and decaying one, either.

Section 2789, Revised Statutes of Ohio, provides that the county commissioners, who hold the same powers (with monthly or semi-monthly meetings) as our boards of supervisors, may authorize the auditor to advertise in one or more newspapers for sealed pro-

posals to furnish suitable plats to enable the supervisors and assessors to correctly appraise all real estate. Contracts are awarded and bonds required for their performance. These plats are kept by the auditor, and tracings are furnished to the township supervisors, assessors, etc., of the various localities. By this system uniformity is preserved, and mistakes in description, either in assessing or in tax-paying, are largely eliminated. In our State the county treasurer would be the proper custodian, and all transfers of title to real estate could easily be made upon the plats, or by marginal reference. So much for the laws required.

In regard to the making of maps, it is hardly to be expected that I can give the members of this Society any advice or information. Some points to be observed are these: A good quality of mounted or muslin-backed drawing paper should be used for original plats, the best of India ink for line and letter work, and color, sparingly, if used at all. A light marginal shading of Prussian blue laid on with a brush, where there are large water fronts or surfaces, will save time and labor, and add to the appearance of the plat, if well done. Tints may be used to distinguish additions, subdivisions, etc., where a number of parts of several appear on the same sheet; but avoid poor colors, and unless one has experience and some artistic ability, the pigments are more useful in obscuring poor workmanship than in adding to the beauty of the plan. Headings may be stenciled in when one has a losing contract. Almost any well-equipped newspaper or job printing establishment can do very satisfactory work in printing headings, and much cheaper than letters can be designed — unless the foreman is very drunk and spoils one's whole plan, as I have had him do for me. Make as neat and artistic a heading as you can afford; for nothing adds more to the appearance of your job — unless it is the rest of the workmanship.

Scales are important, and are usually prescribed in the contract. Usually the first thing the lucky bidder sets about is to have his contract modified in this particular. The scale should be governed largely by the size of the tracts to be mapped. In township work where farms are large, it is an unnecessary waste of paper and material to use the same scale as would be required where the parcels are small. I would recommend for general use in country work scales of 10 and 20 chains, and in village or city work, of 50 and 100 feet, and even as small as 200 feet where lots

or tracts are quite large. Index sheets on a small scale, showing the entire area mapped, should accompany each book; they may show by tints and figure the space covered by the correspondingly numbered page of detail work. Plainly print or write the owner's name and the area in each tract or parcel, showing dimensions or distances, courses or bearings, as far as known, where they belong. In village and city work, get lots and blocks numbered correctly, show width of streets and alleys. Don't be hoggish, and take up all the room, or get your half in the middle of the plat, to print names and area; leave the assessor a place to put valuations on, make changes, etc. The tracings may be made on certain qualities of bond paper, but tracing-cloth or linen is much more durable and satisfactory, and will last the assessor several years, if carefully used. Changes in ownership and value can be made and compared with the originals at the county seat.

I am aware that we already have laws in Michigan which make it possible for maps to be made for assessing purposes, but I consider them lacking in many particulars, and valueless in promoting system and uniformity in this important work.

While I think no one will deny the utility and convenience of such plats, I expect to hear somewhat of the expense involved. The legislation needed is not of the compulsory kind; it is only requisite that it provide that such plats may be authorized by the proper officials when and where the demand exists. Then the cost may be considered, and I apprehend that will not prove such a bugbear as is usually feared. It will not prove much more than is incurred under the present system, by which the plats made have no uniformity, no specified custodian, and soon become worn out and lost. I have seen hundreds of dollars' worth of valuable maps, plats, and records which had been chewed up and utilized by rats and mice in the construction of comfortable nests, all for the lack of a proper legal custodian. The bids for such work in Ohio counties range as far as my own personal knowledge extends, from $500 to several thousand dollars — $15,000 to $20,000 in the counties of Cuyahoga and Hamilton, containing the cities of Cleveland and Cincinnati. The State of Michigan being almost entirely sectionized and most of the counties of moderate size, with small populations and large farms, the expense would be light here in comparison with the cost of such work in Ohio.

ELI L. HAYES.

Prof. Davis. — Perhaps I might say a word with regard to this paper. I think our plat law should be extended to all the land in the State. We should require the use of that plat law or its like everywhere. Every sale of land should be made by a recorded survey. Future sales of those pieces of land should be made subject to the recorded plat thereof. It would be found that the expense in connection with real estate conveyances would be very much lessened in a short time.

Mr. Forster. — Mr. President, I may be very dull, but I don't see now why if I should want to sell my farm, that it would be necessary to go and hunt up a surveyor and pay him to survey it. I know my bounds exactly, and all of my neighbors do. I know where it is, what range, what township, and what section.

Prof. Davis. — I will explain. It is not possible that all farms are in as good shape as Mr. Forster's. But we will suppose they are. Now Mr. Forster will die some time, and as time passes, his farm will change hands. Now there should be a record on file which will describe the exact location of it. While Mr. Forster himself knows all about his bounds, and is satisfied they are right, there is nothing on file to convey the same satisfaction to others.

ON SEWER CURBING.

Mr. President, and Gentlemen of the Convention: —

LAST year I was requested by some of our members to write a paper on sewering in quicksand, with a description of a method of curbing. The subject being somewhat old, and being afraid of its being flavored with chestnuts, I did not respond; but as the request has been repeated this year, I will, as briefly as I can, give a method that has been very successful with me. Of the sewer itself I will say nothing; but take the matter up at the point when the guides are set, and digging is ready to commence, premising the sewer is deep, and in quicksand some feet at the bottom. The most important part to be attended to is the surface ground that overlies the quicksand. To hold this in place, and prevent cracking and crumbling, is of the first importance.

The trench must be perfectly true, the banks free from humps, so that the curbing may bear evenly against all parts. Poor workmen don't do this good enough as a general thing. Did you ever see a poor workman? — I mean a man who could not dig a good sewer trench, letting him be the judge?

I have found but a very small per centage of men who ought to be intrusted to make the banks of a sewer and shape them to fit the stringers, as we call the horizontal planks we use for the work. These should be of good, strong lumber, tolerably free from knots, as they must bear the strain of the braces being as far apart as possible, to allow the workmen room to put up scaffolding. If the trench is deep — say if 12-foot plank is used — the braces would be about 5 feet space in the clear to work in, which is rather small. Fourteen-foot plank would be better.

If 16-foot plank were used, it would likely need a brace at each end, and two at equal spaces, unless the plank was thick and unduly heavy. This horizontal curbing is used as far down as you can depend on the bank to stand, while the ditch is deepened the width of a plank on each side. These should be put in very care-

fully in panels. Don't break joints. If put in exactly over each other, they can be used over and over again. When the trench is filled up, the panel is taken out. Commencing at the bottom plank, loosen the braces, throw them out, slide the plank backward, and fill in the earth. The man in the ditch loosens the next plank, and so on. The planks last for a good many sewers.

By keeping the backfill well up, moving lumber very far ahead is avoided, and you do n't need so much curbing. Leaving lumber in a sewer is a waste. I never left a plank behind in my life. This supposes your workmen are handy men, and are not afraid you are going by faulty arrangements to bury them alive. I have found it hard work to make men careful enough at the top; but if this is neglected, and as they get deeper, the work looks pokerish, and some of the curbing lets dirt down behind it, and shows signs of loosening, then the men in the ditch will look up frightened. They get nervous, and lose confidence in the safety of the place. Then you are in a bad box. Your top has become loose. You can't change your bracing timber. Every move seems to make it worse. When a shovelful is taken out, there are ten ready to fill in its place. Now comes danger to adjoining buildings, and a perplexity, toil, and expense which may generally be avoided if skill and care are exercised, all the way down. I have been in this condition only when men in my absence have neglected to properly curb the top.

Of course there are many places where curbing is only a nuisance; but we are laying a sewer in a quicksand bottom, and we are now supposed to be as deep down as the earth is sound. It may be two feet, or it may be six feet, it makes no difference. Our walls are nearly perpendicular, or only just slope enough to make braces perfectly safe, perfectly true. The curbing touches almost every part of the earth behind it. Every brace is tight, and in a vertical line with each other. This is important. We want every inch between braces, to get up the remaining earth in the trench, to get down the brick, mortar, sewer pipe, and what not. The banks are perfectly solid to receive the additional weight coming on them. We will suppose we have yet to go about six feet in this loose or wet soil. We get 12-foot boards and cut in the middle, and chamfer to an edge one end of each piece. Now set a pair of stringers inside of the other curbing, the braces in line with those already in. These stringers must be good, sound pieces, not too

wide. These chamfered boards must be driven behind them, by placing a hard-wood block on them on end, and driving with a sledge down a little below the dirt in the trench. Lower the curbing, tight together, one man digging, others driving curbing, etc. As soon as this is down some distance, put another pair of stringers. Then dig and drive curbing, putting as many stringers as necessary.

Your chamfered boards may be generally trusted a foot below the lowest stringers, before the spring will bother you. All this may seem a great deal of work, and be very slow, but I have found to secure as you go is the truest economy in working in bad ground. In practice when good men get accustomed to it, and each man knows his place, one holds the stringer; another takes the sliding sticks, and measures for length of brace. The measure is passed to the top, the brace sawed, driven, and the work goes on. In this way, a few men will put in a good stretch of sewer in a day, while if your curbing is poorly managed, small cavings soon become large ones, and great quantities of earth thrown out that should be left in the bank. Every shovelful moved unnecessarily, does but increase the danger and tendency to cave.

Except the bracing stuff, and some splitting of the upright curbing, there is absolutely no waste of lumber. The same planks go from sewer to sewer, for months and even years, if they are not stolen. In the braces there is some waste, as they are split some in the driving, also in the fitting, as after repeated fittings, they get too short.

Here is the place to speak of pipe braces. These are made by filling each end of a piece of gas pipe of suitable length with an iron rod. On one of the ends is a screw and swivel, which squared up turns with a wrench. If it is desirable to move a brace, or set of braces, first secure the work with a new set, to take the strain from those you wish to move. This done, the others can be taken out without trouble. This moving has always to be done, whenever the piece of vertical curbing behind the ends of the brace is driven. The strain must be taken off by changing braces, at which time the piece behind the permanent brace may be lowered twice or thrice the usual depth. When the original or permanent line of braces is restored to place, the temporary ones are removed, and the digging is resumed.

As the less thumping and pounding done the better, extra effort is made to get down a good distance when the change is made. It is best, however, to take as few chances as possible; for if a cave begins ever so little, it is hard to stop. One brace loosens and falls out, then another, till the men get frightened, and won't go where they could do the most good. I have seen as much of a break-up in five minutes, as a large force of men could put right in three days.

I doubt if a very good job is ever done after a serious cave occurs. Having got to the depth of your curbing, and you want another six feet, the same thing is repeated, scaffolding is put in, and the earth thrown up from one to the other, till China is reached, if there is where you want to go; only proportion the strength of material used to the service you require. Now what we have already got, will be all that is necessary, till we come to the place which is the worst place you ever saw. This is a name always given, with stronger adjectives added, to every place where the water boils up with great force, where the workmen can't stand, and must have a device on the curbing to stand on, to keep them from being lost. In these places the sand and water will get through such small cracks it will begin to fill the tunnel of your finished work. Now Mr. Wiseman is on hand, and looks at it and swears he never saw anything like it, nor anybody else. He doesn't believe you will ever make a sewer worth anything. Why, he would n't work in the bottom of that sewer for all the earth and a mortgage on the moon. After disposing of Mr. Wiseman by death or otherwise, to prevent his scaring and discouraging your men, something else is necessary; and, gentlemen, when a place of this kind is struck, I know of no royal road out of it.

The presence of the engineer is of importance to encourage and hold every man to his work; with cool-headed confidence in your own ability, expedients of all or any kind, must be now in order. That sewer is going through, and you are going to do it. A good way after putting a board against the mouth of the sewer (this you no doubt have been using right along), is to get made a boiler iron box, by cutting the sheet a little wider than the sewer tunnel is deep, and of a length sufficient to allow it to be bent so as to form three sides of a square that encloses one of the sewer pipes, or if a brick sewer, then the length of a form, and a few inches to

spare. This is lowered, open end down stream. When down, the open end is kept apart by the completed sewer and a piece of plank two inches on each side for room, the closed end of the box being up the sewer. Now by using old rags, tufts of grass, etc., between the box sides and sewer, you have a tight thing, except the bottom, of a little more than the length of a pipe or form. This is settled till the sides are level with the top of the sewer. Now with the closing board at the sewer mouth, and the box on the other three sides, you are ready for a busy time to get in that section of the work. This done, and it may be quite a job,—but perseverance will do it,—the closing board is put at the mouth of the section just in. Now the box must be raised in such a way as not to injure the finished work. These boxes draw hard. Suitable holes have been left near the top of the box, to which we attach a heavy, strong chain. A long heavy lever with a block fulcrum generally brings it. For small sewers of course it is not so heavy, nor is the suction so bad. In all places of this kind that I have been in, this iron box has always helped me out.

Another thing I will mention. In some of those boiling springs, in spite of all I could do, the finished part of the sewer would get choked with the sand. In such cases I have made a dam a short distance in front of the tunnel, and built up something like a chimney as high as the water would allow. This gives a good head; and if done at night, we have found a clear passage in the morning. The progress through these places is so slow and discouraging I have been blue, but always felt like keeping on, and for the encouragement of younger men, who may meet similar difficulties, I have never had any of those places fail, either by settling or any other way, notwithstanding the cement would seem to cut away as fast as put on. Fortunately, these extremely bad places are scarce, and don't go many feet in any one place. I don't think I ever found 100 feet of such subterranean water-courses at one time, although a troublesome quicksand with lots of water is very common. Now I will leave this subject, lest I bore many who have been there so often, they don't want anything to do with, or hear about, them. Of sewers round, of sewers egg-shaped of sewers large, of sewers small; of systems combined, of systems divided, and of systems mixed, you have had a surfeit: and to add to the plethora, I will say about curbing, Keep the top all right, and

do n't neglect the bottom. The only pleasure I ever discovered in building sewers in quicksand was in getting them finished.

WM. APPLETON.

Prof. Davis. — Have you anything on substructure?

Mr. Appleton. — No; I purposely left all that out, as Latham's excellent work exhausted the subject, and should be in the hands of every sewer engineer.

Prof. Davis. — Well, gentlemen, I have listened with a great deal of interest to Mr. Appleton's experience with sewers in quicksand. Always keep the hole full. I had one job of a foundation in or on quicksand, where I put in the first course by putting the timber in place, and standing a lot of men on it with shovels and working the sand out from under it with their shovels; but I have found that I always accomplish what I start to do by keeping the hole full.

Mr. Hodgman. — Some years since, Prof. R. C. Carpenter, in a paper published, I think, in the *Rural New Yorker*, and perhaps also in the reports of the Board of Agriculture, illustrated the iron box and the method of using it in quicksand. He also called attention to the manner of handling quicksand with the shovel. He says that the shovel should not be worked about in the sand, but inserted carefully, and lifted directly out, the great point being to so use the shovel as not to move or disturb in any way the sand that is left. If this is carefully done, the sand will remain hard, and not run, while a slight disturbance will set the whole mass running.

THE THATCHER SPIRAL BOILER.

I HAVE taken this subject in the hope that my paper might create a discussion which will give something more than theory in regard to the type of steam generators that we shall take up.

Some months ago, through the kindness of a friend in Detroit, I had come into my possession the drawings of the so-called Spiral Boiler which was patented Nov. 6, 1888, by Lewis C. Thatcher, of Chicago. It consists of a series of hollow spirals constructed about a central core, and resembles in appearance an immense *V* threaded screw. The inventor proposes a double coil or a double threaded screw, claiming that that form recommends itself both for simplicity and for effectiveness of water and flue space. The flanges on the sheets forming the upper surfaces of the thread are turned down at the outer and up at the inner edge, while those on the bottom sheets are the reverse, so that the two sheets are connected directly to each other at the outer edges, and the top one to the lower one of the next spiral at the inner edges, thus forming the core.

The steam drum is added at the top, and by means of trussing inside this drum, the boiler is carried on the furnace walls which encircle it, so that entire freedom of expansion is allowed. A mud drum may of course be added at the bottom of the central core, if thought advisable. The top and bottom sheets of each spiral are stiffened by link stays inside. The man-hole is in the steam drum, and through this a man can be admitted to the core of the boiler, from whence he can reach with his hands every part of it. The furnace, the inventor proposes to divide, so that one half may be connected with each of the spirals. As to the necessity, advisability, or disadvantages of this, we are not prepared to express an opinion.

The inventor names as the objects aimed at and advantages of this boiler: —

First, The securing of a boiler wholly within the combustion chamber, whereby the loss of heat from radiation may be reduced to a minimum, and the rendering possible the use of the last available units of heat in the furnace gases to superheat, the steam; for it will be borne in mind that while the highest pressures yet in use in our boilers do not call for a temperature of over 350° Fahr. in the steam, the gases are almost never discharged to the chimney at a lower temperature than 500°.

Second, The exposing of the entire surface of the boiler to heat. This will not only increase the possible heating surface, but also will prevent unequal expansions and contractions with detrimental strains.

Third, A long and continuous fire flue. This insures a good draught with a great exposure of surface to the heat of the gases.

Fourth, A boiler free from obstructions in cleaning. This is an advantage that must be appreciated by all who have handled boilers.

Fifth, A form in which the line of disengagement of steam particles is freely upward.

On the other hand, one very serious objection to it would be the difficulty in its construction, for its surfaces are "warped," and hence cannot be developed on a plane; and so they could not be formed from plain sheets in the ordinary manner, but the sheets would probably have to be stamped into form while hot. It would also seem that this form of construction would require greater thickness of sheets than the ordinary for strength.

To consider the boiler as designed by the inventor more specifically, the central core is 2′ 6″ outside diameter, and the coils are 7′ 6″ outside diameter, which is the inside diameter of the furnace. There are two coils with a pitch of 24″. The space occupied by the lap between the two coils is 3″, which forms the shell of the core. The slope of the elements of the spirals is therefore 9″ in 30″, the bottom elements of the spiral being horizontal.

The projected horizontal breadth of the spiral is $\frac{7' 6'' \; 2' 6''}{2} =$ 2′ 6″, and the mean diameter is 7′ 6″ — 2′ 6″ = 5′ 0″. The projected curve of the center of an element of the spiral will therefore be a circle whose diameter will be 5′ 0″, and its circumference very nearly 16′ 0″. Since during each rotation of the spiral every point

in the generating element rises 24″, the length of the path of the center of that element during a single resolution will be the hypothenuse of the right-angled triangle of which the circumference, 16′ 0″, is the base, and 24″ is the altitude, or 16⅔ feet nearly. The breadth of the bottom surface of the spiral being 2′ 6″, the area of the under surface will therefore be 40.3 square feet. The breadth of the top helicoid will be the hypothenuse of a right-angled triangle, of which 2′ 6″ is the base and 9″ the altitude, or 2.61 ft., and the area of the top for each turn will be 41.1 sq. ft.

The volume of each turn of the spiral will be equal to the area of the generating triangle. 9″x30″=270, sq. in. multiplied by the path of its center of gravity. The center of gravity of this triangle will be very nearly ⅓ of the distance from the short side, and the diameter of the circle of its projected path will be 2′ 6″+1′ 8″=4′ 2″, and the circumference will be nearly 154 inches, and the path of the center of gravity will be equal to the hypotenuse of a right triangle with this for its base and 24″ for its altitude, or 161 inches nearly. Hence the volume of one turn of one spiral will be 43.524 cubic inches. The surface of the core exposed for one turn would be equal to the product of its exposed width 3″, and the hypotenuse of a triangle whose base was twice the circumference of the core, and whose altitude was 24″, or 194 sq. in., and its volume would be 24″×742.6 sq. in.=17822 cu. in.

To determine the number of turns that are necessary, we must discover, if possible, the temperatures of the furnace and the chimney. Practical considerations with reference to draught, limit the temperature at which the gases shall be discharged from the furnace to not less than 500°, and 600° is really a closer approximation to ordinary practice. Assuming the temperature of our furnace to be 3000° Fahr., and referring to a table of the values of heating surface founded on Rankine's well-known formula $\frac{(ta-tb)^2}{a}$ $=q$, we find that starting with a temperature of 3000°, it would reduce to 570° at the 155th foot. We therefore should have 155′÷16.12′=9⅔ turns. Our total heating surface would therefore be, omitting the steam drum, of course,—

Top helical surfaces	42.1×19⅓=	813.9 sq. ft.
Bottom " "	40.3×19⅓=	779.1 " "
Core	194″×19⅓=	26.0 " "
Area of core in fire box = 94 × 24 = 2256″″ = say		16.0 " "
The total volume would be		1635.00 sq. feet.

Volume of spirals	43,524 cu. ins. $\times$ 19⅓	= 841,464 cu. ins.
" " core	17,822 " " $\times$ 10⅓	= 184,161 " "
		1,026,625 cu. ins., = 594 cu. ft.

So that for every cubic foot of water or steam in the boiler there is 2.75 sq. ft. of surface exposed to the heated gases.

As to the area and volume of the gas passages, they will be generated by the helical motion of a trapezoid whose parallel sides are 3″ and 12,″ and whose breadth perpendicular to these sides is 30.″ By a graphical construction we determine the center of gravity of the trapezoid to be about 18″ from the inner end or the core. The core being 30″ in diameter, the diameter of the circle of the projected path of this c. of g. will be 30″ + 36″ = 66,″ and the circumference will = 207.3.″ The path of the center of gravity will be equal in length to the hypotenuse of a right-angled triangle whose base is this circumference, and whose altitude is 24,″ which = 208.7″ per turn. The area of the trapezoid = $\frac{3+12}{2} \times 30 = 225$ sq. in. So the volume of one turn = 46,957.5 cu. in. = 27.17 cu. ft., and for 9⅔ turns of each spiral the volume will be 27.17′ $\times$ 19⅓ = 525.29 cu. ft. Total area of gas passages = 3.7 sq. ft.

It is an established principle in boiler construction that the grate area should not be more than seven times the area of the gas passages. Taking an ordinary value for the ratio, we will make our grate area 6 $\times$ 3.7″ = 22.2 sq. ft. If the grate be situated 34″ below the bottom of spiral, allowing for a 10″ fire, the volume of the furnace would be 2′ $\times$ 22.2 sq. ft. = 44.4 cu. ft. Total volume of gas passages 44.4 cu. ft. + 525.29 cu. ft. = 569.29 cu. ft.

We therefore have, recapitulating,—

Total grate area,	22.2 sq. ft.
" heating surface,	1635.00 " "
" volume of water and steam independent of drum,	594.00 cu. ft.
" " of gas passages,	569.30 " "
Ratio of heating to grate surface,	73.65
" " " surface to contents of boiler,	2.75
" " " " " " " gas passages,	2.87

For purposes of comparison, we will find the same data in an ordinary horizontal tubular boiler, 5′ 6″ diameter of shell, 14′ 0″ long having 82 — 3½″ tubes, and set with a calorimeter 30″ high at the lowest point. We find —

Total grate area = $\frac{1}{8}$ of tube area,	33	sq. ft.
" heating surface, including both front and back,	1285	" "
" volume of interior of boiler,	255.92	cu. ft.
" " " gas spaces,	417	" "
Ratio of heating to grate surface,	39	
" " " surface to volume of interior,	3.6	
" " " " " " " gas,	3.1	

First, considering the question of grate area: From experiments made upon a marine boiler at the Brooklyn Navy Yard, as well as from many others, we discover that reducing the grate area, and burning the same amount of coal per foot of grate, increases the efficiency of the boiler.

D. K. Clark is authority for the statement that the performance of a boiler, other things remaining constant, increases as the square of the heating surface.

So far the advantage seems to be with the Spiral Boiler, but when we come to a consideration of the ratio of the surface of the water exposed, to the volume of the water, the tubular boiler has a decided advantage, as for every cubic foot of water it contains it exposes 3.6 sq. ft. of surface to the heat, while the Spiral Boiler only exposes 2.75 sq. ft. So also for every cubic foot of gas generated, the tubular boiler exposes 3.1 sq. ft. of surface, while the Spiral Boiler exposes only 2.87 sq. ft.

But the form of the gas passages are such, we think, as to overcome partially this disadvantage. On account of the spiral form of these passages, the gases would be caused to whirl and rotate while passing along, thus bringing every particle of gas into contact with the plates, and mixing thoroughly the gases with the air. This latter is a very important point, for while the percentage of loss of heat by radiation and stoking can be reduced to almost nothing, there is a certain amount of heat that must be carried up the chimney by every pound of air, so that if more air be admitted than is absolutely necessary for the combustion of the fuel, it causes a dead loss of heat, for it all has to be raised to the temperatrue of the discharged gases, and the heat so used is of no further avail. It is further to be noted that in Isherwood's experiments when with a consumption of 16.57 lbs. of coal per foot of grate he got an evaporation of 7.94 lbs. of water per pound of coal with his whole heating surface; when he cut out his tube surface, which amounted to 70 per cent of his total heating surface, he got an evaporation of 5.91 lbs. of water per pound of coal or of 74½ per cent as great. This

shows that it is essential to bring the flame itself into connection with the boiler plates as much as possible, and for this purpose the spiral boiler is especially adapted.

In the Spiral Boiler the exposed surface of that portion of the gas passages which would contain flame, is much greater in proportion to the volume than in the case of an externally fired tubular boiler.

Theoretically for the combustion of 1 lb. of carbon, only 12 lbs. of air must be consumed; but in practice it is found that many boilers require 25 lbs. of air per pound of carbon. There are boilers, however, that work on only 15 lbs., and as the amount of air required is largely due to the intimacy with which it is mixed with the particles of gas, it would seem that the Spiral Boiler should have a very low requirement. Moreover, this same question of intimate mixing of gases and air is at the basis of the prevention of smoke. The appearance of smoke is an evidence of a waste of fuel, and if the products of combustion are properly mixed with a proper supply of oxygen, it should not appear.

Let us now figure theoretically the possible efficiency of a boiler: —

If we assume that we discharge the products of combustion into the chimney at a temperature of 600° Fahr., and that it requires 15 lbs. of air for every 1 lb. of coal burnt, there must go to waste an amount of heat determined as follows:—

The products of combustion of one pound of coal and 15 lbs. of air will be $3\frac{2}{3}$ lbs. of C. O_2., $\frac{2}{3}$ lb. of O., and $11\frac{1}{3}$ lbs. of N. Multiplying by the specific heats, we have —

C. O_2.	$3.7 \times .217 =$	.8029 *H. U.*
O.	$.7 \times 2.18 =$	1.526
N.	$11.7 \times .244 =$	2.855
Total,		5.184 *H. U.*

which is the amount of heat necessary to raise the temperature of the discharged gases 1° Fahr. Now if the gases are discharged at 600°, and the air was admitted at 60°, the total heat required to be wasted will be (600° — 60°) + 5.184 *H. U.* = 2799.36 *H. U.*

A pound of coal will generate 14,500 H. U., so on our supposition there is left available 14,500 H. U. — 2799.36 H. U. or 11701 H. U. or $80\frac{7}{10}$ per cent efficiency is possible. In order to increase this efficiency, we must either decrease the quantity of air required, or we must discharge the gases at a lower temperature than that as-

sumed above. The two things working together for the object of discharging the gases at this temperature is primarily to obtain the requisite draught, and the more air required, the greater must be the draught, and the hotter the discharged gases. Then, too, if we compare the Spiral Boiler with one of the old type having the same heating surface, it will be seen that the friction and losses of heat due to contractions and enlargements must be appreciably greater in the old type than in the spiral, and hence the Spiral Boiler will require less draught than a boiler of equal capacity of the older types. It, therefore, seems that this boiler should be a very economical one, and we should feel like giving it our indorsement were it not for a few other points that must be considered later.

This boiler has another advantage over the horizontal tubular or any horizontal boiler; viz., the small floor space required, as for the present boiler of about 100 H. P., allowing 16″ walls for the furnace, only a circle 10′ 0″ in diameter would be required of floor space, but the hight would be about 28 ft., including the steam drum.

Among the points which must be carefully considered, is that of circulation, and the conditions that are likely to exist on the extreme edges of the spiral, also whether the pitches given for the spiral and for the surface of the upper helicoid are sufficiently great to allow of a free disengagement of the steam particles, as the inventor claims. This is one of the points upon which we must rely upon experience, as also in the question of the ease of entry of the cooler water to the spiral portions, to replace the steam as generated. Then there further comes in the question of stays as to the number and position and the obstructions they must offer to cleaning, and to the liberation of the steam particles. The above, with the subject before referred to of the difficulties of construction on account of the warped surfaces involved, must be the ones that will control the future success of this type of boiler.

G. S. WILLIAMS.

WHO OWNS THE LAKE BEDS?

THIS is a question of a great deal of interest to the owners of lots made fractional by small lakes within the regions subdivided by the United States Survey. It has been debated pro and con for many years, and in at least one case a State has been at law about it.

There are two questions in relation to these lake beds which are of interest to surveyors.

1. The primary question already mentioned, who owns them?
2. How are the boundaries between owners to be determined?

As to the first question, it is pretty certain that these lake beds belong either to the United States, to the State, or to the riparian owners around the lake. One view which seems to differ from the generally accepted views on these points, is held by the Supreme Courts of Michigan and Indiana.

In Klute *vs.* Fisher (31 N. W. Rep. 614) the Michigan Court says: "The true and only rule is to invest the holder of the title of any fractional subdivision of a section bordering on a lake with the ownership of the bed of the lake to the lines of said subdivision, *as they would be if continued through or into the lake.*"

More recently the Supreme Court of Indiana has ruled (Stoner *vs* Rice, 22 N. E. Rep. 968) that "when an inland non-navigable lake covers a portion of a section of land, and the government survey designates the dry land in each subdivision as a fraction or a lot, the purchaser from government of such lots acquires title to *all that portion of the bed of the lake included in the whole subdivision.*"

The principles thus laid down would work very nicely in a great many cases, and the riparian owner and surveyers would have plain, easy sailing till they happened to come across one of the many cases where these principles would not fit. I will comment on these decisions further on. On the other hand, while it is universally conceded that the bed of a lake which was not meandered by the United States Survey belongs to the owners of

the adjacent shore, it has not been generally so conceded for the bed of a meandered lake. The land department of the United States, so far as I can learn, has never conceded that their conveyances of fractional lots carry the beds of the lakes with them. Up to 1877, they made regulations by which the beds of meandered lakes becoming dry by natural causes, might be surveyed and sold, and many of them were surveyed and sold accordingly. Since that time they have refused to survey and sell such lake beds except in a case where it was shown that the original returns were fraudulent, and that in fact there never was a lake where the official plot and field notes represented one to be. This refusal to survey and sell such lake beds, has been placed on the ground that there was no law authorizing the survey and disposal of meandered lakes. Secretary Lamar adds in a ruling, July 12, 1887: "Besides, I am not satisfied that the bed of this lake does not inure to the owners of the adjacent tracts upon the principle of accretion as ruled in Boorman *vs.* Sunnuchs (42 Wis. 233), and in Forsyth *vs.* Smale (7 Bissell 201)." It was concerning such lakes that Judge T. M. Cooley said: "There are many lakes and ponds which are gradually disappearing, and the shore proprietorship advances *pari passu* as the waters recede." But it could not so advance nor could the bed of the lake inure to the shore proprietors on the principle of accretion, if they owned it as ruled in Klute *vs.* Fisher and Stoner *vs.* Rice.

In Forsyth *vs.* Smale it is ruled that "the grant includes any land between the meander line and the water in an unnavigable stream, and that the same principle applies to unnavigable lakes." In Wisconsin it is ruled in Boorman *vs.* Sunnuchs and Deidrich *vs.* N. W. U. Ry. Co. (42 Wis. 271), that the riparian owner upon a natural lake or pond takes only to the natural shore, and that the boundary lines should be extended according to the rule for accretions in navigable waters.

In Eversen *vs.* City of Waseca (46 N. W., Rep. 405), the Supreme Court of Minnesota ruled that a patent from the United States of a surveyed subdivision bounded on a meandered lake, conveys the land *to* the lake. In the case of the State of Indiana *vs.* Milk, in which the ownership of the bed of Beaver Lake was at issue, Judge Gresham cites numerous authorities to the effect that "a grant to a natural pond or lake extends only to the water's

edge," and adds: "By their purchase of the abutting tracts, Dunn & Condit acquired title to the water's edge, and no further."

The writ of authority seems to be clearly against the abutting proprietors having any title to land under the waters of meandered lakes. It must then belong either to the State or the United States.

It has been ruled by the Supreme Court of the United States in County of St. Clair *vs.* Livingston, that "the United States never had any title to land under the navigable streams and lakes." This is on the ground that in the original cessions to the United States they were expressly reserved for use as public highways. In such a case, the title would be in the State. It would be interesting to know how far that decision reaches, and how we are to distinguish between a navigable lake and one not so.

What is to determine the question? Is it size, length, depth, either or all combined? and, if so, what is the size, length, and depth required to make navigable lakes of them, and place the title in the State? Many of our small lakes are navigated by boats of large size, and many more might be. Steamers of as great draft, as those navigating many of our rivers, carry pleasure parties from place to place, and tugs haul rafts of logs and scow-loads of wood along their surface. If the same rules of law which the United States Courts apply to streams apply also to lakes to determine whether or not they are navigable, then a goodly proportion of our meandered lakes are also navigable lakes, and the United States having never had any title to them, could not convey any title to their beds by the sale of the abutting tracts.

It would seem, then, that we have three classes of lakes,—

1. The unmeandered lakes which are bought and paid for the same as the dry land by the purchasers of the abutting tracts, and of course owned by them.

2. The great lakes and so many of the smaller lakes as may be determined to be navigable, in which the beds are owned by the State.

3. Unnavigable meandered lakes in which the title is in the United States.

In the first class, it is believed the public have no rights whatever. In the second and third classes, they have rights of fishery, ice-cutting, etc., which may be and are regulated by public authority.

We now come to the question of how the boundary lines shall be extended or located in the lake beds. The answer depends almost entirely on the question of title. If the title of the abutting owners stops at the water's edge, as held in the cases cited, in case the water recedes, the boundary line will be extended according to the laws governing accretions, which are supposed to be familiar to the members of this Society. (See Manual of Land Surveying, Fifth Ed., p. 279.)

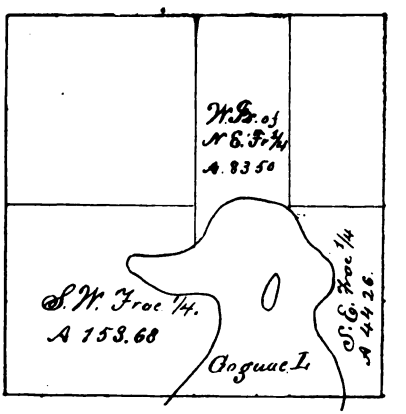
If, on the contrary, the abutting owners own the lake beds also in the manner held in Klute *vs.* Fisher and Stoner *vs.* Rice, then the boundary lines are to be located on the same principle as if there was no water there. This view of the case does not seem to me to be sound or just, as a general principle or rule, while at the same time in many cases it would be a very convenient rule, and do no special harm; but,—

1. The government did not sell the land that way. It has never been conceded by the land department that they sold the land under the waters of meandered lakes. When the lake is not meandered, they sell it, and charge the purchaser the same price per acre that they do for the upland. Would it be just to make one man pay for a lake which is not meandered, and give to another man for nothing the lake that is meandered? It was not so intended.

2. There are hundreds if not thousands of cases in which this Michigan and Indiana rule cannot be enforced without disturbing vested rights which have been thoroughly settled by the courts. There are fifty or more such cases in my own county alone. The act of 1820 (R. S. 2397) provides that fractional sections shall be subdivided into quarter-quarter sections under such rules as may be prescribed by the Secretary of the Interior. Under that statute, the Secretary of the Interior prescribed rules directing that such sections be divided by north and south or east and west lines, so as to preserve the most compact and convenient forms. It has been definitely settled that these rules were valid and lawful. (See Gazzam *vs.* Phillips lessee 20, Howard 372.) Under these rules it has been the custom of the land department ever since to divide these sections so as to preserve compact and convenient forms. In doing so, they have frequently attached small outlying fractional lots to an adjoining larger tract, and sold the whole by a description derived from the larger tract. These

outlying fractions have not always been in the same section, or even in the same township, as the tract with which and by name of which they were sold.

Take, for instance, Section 14 in the township of Battle Creek, Mich. The cut gives a correct idea of the official plat of that section, and the manner in which it was sold. Goguac Lake lies partly in the section, and has an island lying wholly in the south-east quarter. This island was meandered and sold by itself, and has ever since been occupied by the grantees who derived title from the United States Government. There is a tract of several acres lying west of the lake and east of the north and south quarter-line which is entirely separated by the lake from the rest of the south-east quarter. It was attached to and sold as a part of the south-west fractional quarter. The north and south quarter-line was not extended across this tract on the official plat of this section. There is another small tract in the south-east quarter, but entirely cut off from the rest of that quarter by the lake. It was attached to and sold as a part of the west fractional half of the north-east quarter. The remaining tract lying east of the lake was sold as the southeast fractional quarter. Now suppose we attempt to apply this new Michigan-Indiana rule to this case, and see how it works. If as in Stoner *vs* Rice, the purchaser of the southeast fractional quarter is entitled to the entire quarter section, he must take away the island from one man, and the tract north of the lake from another, and the tract west of the lake from another, in order to get what belongs to him. But the Supreme Court of the United States (Gazzam *vs.* Phillip lessee) says that cannot be done, and the Supreme Court of Michigan too (Wilson *vs.* Hoffman, 38 N. W. Rep. 558), says that cannot be done. Then what becomes of the principle laid down in Stoner *vs.* Rice? and how are we to determine the boundaries of the island and these outlying fractions on the principles laid down in Klute *vs* Fisher? That cannot be



done either. The only way such cases can be rightly adjusted, is on the grounds that the owners of the abutting tracts do not own the bed of the lake. But it may be said, This is an exceptional case. Not so; on the contrary, it is a very common case. The township of Ross alone, in Kalamazoo county, has sixteen tracts of land similarly situated.

Lastly, we may refer to the official plats of the government survey as having some bearing on these questions: "Lands are not surveyed lands by the United States until a certified copy of the official plat has been filed in the local land office." (United States *vs.* Curtner, 38 Federal Rep. 1.) This official plat defines the location and boundaries of the various tracts into which the section is subdivided. In Gazzam *vs.* Phillips lessee, the Court tells us the sales to Stone and Etheridge "were in conformity with the official plat then on file in the local land office." It determined the extent of their grants. This is the regular course in all government sales of the public lands. Now I find in all the official plats that I have examined, and I assume that it is the same with most if not all of them, that *no part of a meandered lake is included within the marked boundaries of the abutting tract*, and hence is not included in the sales of those tracts. On the official plats, neither township, section, nor any subdivision lines are extended across these lakes. They are entirely segregated from the surrounding tracts.

Resume: From these considerations, I think we may conclude that it is fairly well established, where the United States Survey extends,—

1. That the beds of non-meandered lakes belong to the owners of the adjoining land, and the boundaries are found the same as if no lake were there.

2. That the beds of navigable lakes belong to the State.

3. That the beds of meandered non-navigable lakes belong to the general government.

4. That in the second and third cases above, the proprietors of the adjoining lands own to the water's edge, and in case the water recedes, their boundary lines will be extended in accordance with the laws governing accretions. (Since the above was in type, I have received a copy of the ruling of the Secretary of the Interior, April 29, 1891, in the case of Popple and others, in which the matter is fully considered, and it is held that the bed of Crab Lake, a meandered lake, belongs to the general government.)

F. HODGMAN.

NOTES ON ENGINEERING IN NICARAGUA.

In February, 1881, I was called to take a position as transitman with Frank P. Davis in a party engaged in the location of what is now the Denver & Rio Grand Western Railroad in Utah. A young man of Climax, named E. U. Hunt, decided on an hour's notice to go with me, and take his chances of getting work when he arrived there. He had a fair common-school education, and had been at work by the month on a farm, and saved his money till he had enough to pay his expenses to Salt Lake City, and some besides. He was assigned to our party, and I put him at the head of the chain. He put in all his spare time in learning the use of instruments, how to run curves, etc. It was not long till he was competent to do anything we had to do on the line. In a short time I was assigned to a party of my own. Hunt staid with Davis, who gave him plenty of opportunity to advance. Before the end of a year, Davis was resident engineer in charge of all the work from Green River to Clear Creek, about 200 miles, and Hunt had done nearly everything from chaining to track laying. In March, 1882, that job ended. I came home. Davis went in charge of a locating party in the Rocky Mountain Division of the Canadian Pacific, and Hunt went with him. They staid there two years, Hunt as transitman the last year. Then Davis returned to his home in Washington, and Hunt invested his spare cash in a Kansas farm.

When the Nicaragua Canal was ready for a survey, Davis got a position on the engineering staff, and sent for Hunt, who accompanied him there. He is now at his old home in Climax, on a vacation, and I jot down a few of the odds and ends that I have picked up in conversation with him. The party sailed from New York, October 28, 1887. At Jamaica they took on about 100 negroes for workmen. They had about nine months' supplies with them. They reached Greytown early in November, and went up the San Juan River by boat about forty miles to an island on

which they established a permanent camp. The canes were so thick here that they were obliged to cut them before they could land.

About the first thing on landing, the darkies found a big tobova five feet long, which scared them so that it was at least half an hour before they could be induced to go to work. The tobova is a poisonous snake something like a rattlesnake, with immense fangs an inch to an inch and a half long. The poison passes down the inside of the fang, and is ejected from a small hole near the point. Its bite is sure death. Fortunately, it is a very sluggish serpent, and not at all aggressive, never seeking a quarrel. For a month Hunt had charge of the work on the island, putting up offices, store-houses, tents, and all the necessaries for a permanent camp.

In the meantime, Davis went up the river five miles to begin the survey. His party went in small steel boats, of which the company had a number. The river was so full of logs and snags that it took them five days to go the five miles. This camp on the island was for the headquarters, from which the different parties were to receive supplies and orders. The San Juan River rises in Lake Nicaragua, and empties into the Caribbean Sea at Greytown, running 120 miles to get sixty-five on a straight line. It is from 1,000 to 1,500 feet wide. In going up the river the first four or five miles, the banks are low and swampy, and covered with a dense growth of vines and silico palms.

Further up the river, the banks are higher, and covered with large trees and wild cane. At twenty miles are quite large hills, spurs from an interior mountain range. At forty miles by river is Camp Carejo, on the island before mentioned. Forty miles further on at the foot of Castillo Rapids, is the old Spanish Fort Castillo, where Walker tried to take Nicaragua. The ruins of the fort are there yet, with a few bare-footed soldiers to guard them. Forty miles further is the lake, a sheet of fresh water about forty by ninety miles in extent. Two mountainous islands rise out of the lake to a hight of over 5,000; one of them was an active volcano for several years, and only went out a short time before the party arrived there. The lake and river are full of fish, sharks, and alligators. From the west side of the lake to the ocean is only seventeen miles of rocky volcanic soil, having five to sixteen feet of black loam on top, and disintegrated rock below.

The upper 65 miles of the river is to be slack-water navigation. To effect this, a dam 52 feet high and 1,000 feet long is to be thrown across the river. It is to be a rock-fill dam, the material for which is to come from the big cut in the divide, about 12 miles away, from which it is to be brought by rail. One of the jobs to which Hunt was assigned was to make borings for the dam. For this purpose he was furnished with a derrick and augers, and negroes to run them. About the first thing he did, was to dispense with the derrick, get a pair of climbers, and attach his head block and tackle to the trees above. This was a great saving in time and labor, as there was no moving of derrick to be done.

He also made borings the whole length of the canal line. These were carried down to the grade line of the canal, or to rock. Dif ferent sized augers, from 1½ to 4 inches, were furnished him. The 2½ inch worked very much the best, and was about the only one he used. Along the beach it was impossible to bore in the sand, and he procured a pipe and point, the same as are used in drive wells, and explored the earth with that. The same apparatus was used in the harbor, and the pipe driven from a platform laid across two boats. When he went to make the borings on the west side, he was furnished with an interpreter, and got his help from the natives. These all spoke Spanish, and Hunt and his interpreter were the only English speaking men in that part of the country. Hunt per force learned Spanish, and it was not long till he could understand it, although he had not the language at command to speak it himself to any great extent.

The men were bright, active, and willing, and very much preferred receiving their orders direct to getting them through the interpreter, and it was not long till they were able to dispense with his services. When the men got a few words of directions, they were quick to "catch on" to the rest. On the east side, things were different. The negroes spoke English, and had to be watched and directed all the time. Another piece of work intrusted to Hunt was running the flowage line along the Chanchos River, a tributary of the San Juan emptying into the latter above the dam. This was simply tracing the 106-foot contour; but owing to the character of the country, which is cut up with small streams and ravines, and covered with a dense growth of trees and undergrowth, it was a difficult and trying job. The line would frequently make a long sweep, and return within a few feet of itself.

At another time Hunt had charge of a locating party, locating the line of the railroad from the dam down. This railroad line follows the canal, and is practically the key to the whole work. At the divide there is a rock cut, averaging about 200 feet deep for three miles; a single short pinnacle runs up 325 feet. The main work on the canal lies in that cut. All the rest of it can easily be done quicker than that one cut can. The rock must be taken out of the cut, and put into the dam a dozen miles away, and the railroad must be built to carry it there. Up to the present time, less than a dozen miles at the lower end have been built.

As may be supposed, the location of the railroad line was no easy task. The ground was so rough, and the vegetation so thick, that every foot of the ground had to be gone over. One might be within ten feet of a good-sized hill, and not know it. Preliminary lines were run, and then at every 200 feet, cross sections were run out each way, and leveled. A map was then made showing 10-foot contours of the strip. The location was then made on the map, and afterward reproduced on the ground. It was found here, as it has been elsewhere, that the first cost of a road on a tangent through an obstacle, is frequently less than on a curve around it. The stakes used were round sticks cut on the ground as wanted. They were not driven, but pushed down by hand in the wet clay soil as deep as needed. They frequently sprouted and grew. The machete was about the only tool used in cutting brush and opening the line. In fact, the natives use it for almost everything, from cultivating their gardens to smiting their enemies. It is a heavy knife two feet long and two inches wide. It is wielded in one hand, and saplings as large as a man's arm are sometimes cut at a single blow with it.

One trouble the parties had to contend with was the rain. During the rainy season it rains about all the time, and work must be done in the rain if it is done at all. Out of doors everything is soaked. Inside everything is damp and moldy. Everything rusts that can rust. Books fall to pieces. Everything falls apart that is put together with paste or glue. For rain and mud, Nicaragua "takes the cake." At Camp Carejo the rainfall in January, 1888, was 30 inches, in July 34 inches. Total for the year, 19 feet, 6 inches. There is no doubt as to where water is coming from to fill the canal. The climate is not excessively hot, but enervating. A two-mile walk exhausts a man. Hunt says that many a day

after working in the thickets or swamp up to his arms in water all day long, he would come in all used up, and ready to sink the whole country out of sight if he could. Then he would take a bath, change his clothes, and lie down; and in a little while he would feel as fresh as a lark, and ready to swear there never was so delightful a climate as in Nicaragua. He has been there since 1887, with the exception of two short vacations, and has not been sick in bed a day, and there has been but very little sickness among the employees of the company — no more than is usual in the States.

A little over a year ago Messrs. Perry and Hunt made a re-location of the canal line through the divide. They were the only white men in the party, and had all the instrument work to do. A strip of land 1,000 feet wide was cross-sectioned every 200 feet. They did not succeed in shortening the line any, but saved half a mile of 200-foot rock cut. This work was completed in March, 1890. Hunt was then assigned to work on the harbor improvement at Greytown, and put in charge of the work on the jetty. The prevailing direction of the waves here is such that they strike the shore at an angle, which keeps the sand constantly moving along the coast in one direction. This driving of the sand along the coast has filled up the mouth of the harbor. A jetty is being run out to stop it. This has had a double effect — stopping the moving sand on the one side, which piles up against and strengthens the jetty, while on the other side the incoming waves carry the sand away, thus helping to open the harbor, which before they had closed.

The jetty is made of a double row of piles 35 to 50 feet long, and fastened together at the top by caps 14″x 14″x 42′ drift bolted with 1¼″ bolts. Four pile-drivers having 2,800-pound hammers were used. The piles and caps were all creosoted at the rate of 16 pounds of creosote to the cubic foot. They are very heavy to handle. A nail driven into one of them stays there. It can't be pulled. In getting them into place, a track was laid along the jetty as fast as it was built. Nothing better being procurable for a conveyance, the bodies were taken off from some dump cars, and a long reach made of a pole was put between the wheels, and the timbers run out on these extemporized logging cars. In putting the caps into place, two of the pile-drivers were utilized. Cables from them were attached to each

end of the cap, when it was raised and swung into place with little effort. The first piles on the beach were driven with hammers. All the piles were driven 20 feet into the ground. As they went out into the water, it became more difficult to drive them. The piles would break, and curiously enough, they always broke at the surface of the water. A steam pump had been provided, and Mr. Menocal recommended that Mr. Hunt try the water jet. Hunt replied that he knew nothing about it. He never saw one. Neither had Mr. Menocal. There was not a man in the place who had ever seen a pile driven by a water jet.

Experiments were in order, and at it they went. An iron pipe as long as the pile was attached to it. Hose from the steam pump was attached to the top of the pipe, and a brass fire nozzle to the bottom. It did not work. First it had to be bent so as to throw the stream directly under the bottom of the pile. Then the hole was not big enough. A larger one was tried which was an improvement, but not a success. Then Hunt had a point made by drawing down a piece of the tubing, and put that on. It worked all right. Then they had trouble in keeping the tube in place on the pile. That was solved by running it through a staple at the bottom of the pile and another at the top, with chains wound around the top of the pile, and fastened with staples. They were not long in learning that the water jet must be started before it reached the ground, and kept going till the pile was down. Otherwise it would not start at all, and the water was sure to find a vent somewhere, generally by bursting the hose or breaking the connection with the pipe. In driving the pile it was brought to place in the pile-driver, and connection made with the pump. Then the jet was got under good motion, the hammer let down with its weight resting on the pile, and down it went. The hammer kept the head of the pile in place, and helped to push it down. When it was down far enough, the tube was pulled out, and the pile given a few raps with the hammer by way of emphasis. Brush mats were put in back of the piles, and dredges inside hoisted the sand out of the harbor, and deposited it back of the jetty. F. H.

LEGAL DECISIONS.

THE following decisions of interest to surveyors are from the law reports published by the West Publishing Co., of St. Paul, Minn.: —

1. The written explanation accompanying a plat stated that it was a plat of certain land "in blocks or squares by the drawing of lines across said ground where the center line of the street will come when the same is platted to correspond with the C. plat and the streets in this plat; it being the intention to plat said grounds, or in the event of their being sold to provide for their being platted, to correspond with contiguous ground already platted." *Held*, that this did not constitute a dedication of land for streets between the blocks.— *City of New Albany vs. Williams* (*Ind.*), 25 *N. E.* 187.

2. Persons who had dedicated to public use a certain strip of land known as "Park Place," running through the center of a street, with highways on either side, agreed in writing to relinquish all their reversionary rights in said land, upon the condition that a street be constructed through it, and that the title in the highways vest in the abutting lot-owners. The written instrument described the land first as "Park Place," and then again as a "strip of land lying in the center of a street running east and west between First and Brook streets," but Park Place extended beyond Brook street. *Held*, that they thereby relinquished all their rights to the whole of Park Place, and that the title in the highways along the land, including those portions beyond Brook street, vested in the abutting lot owners. — *Allen vs. Reinhardt* (*Ky.*), 14 *S. W.* 420.

3. Where the title of the public to a highway rests upon both dedication and prescription, and the evidence tends to support the title on either ground, the act of the dedicator in building a barbed-wire fence in the limits of the road, after many years of adverse use by the public, cannot be given weight as an act indicative of an intention to revoke the dedication already ripened into title. — *Bartlett vs. Beardmore* (*Wis.*), 46 *N. W.* 494.

4. A deed described the land conveyed as beginning at a certain rock, and running thence one mile east, one mile north, one mile west, and one mile south, to place of beginning; and also stated that it was the land set off to a certain Indian under a treaty with the government. The Indian had previously selected his land as "a tract one mile square, the exact boundaries of which may be defined when the surveys are made." After the deed was given, the Indian's land was located and patented so as to include 640 acres not in the form of a square, no part of which lay within the boundaries named in said deed. *Held*, that the deed, being for a specific tract of land, could not be construed to convey the grantor's interest in the land actually patented to the Indian.—*Prentice vs. Northern Pac. R. Co.*, 43 *F.* 270.

5. In a suit to quiet title, a deed was offered in evidence in which the land was "bounded and particularly described as follows, to wit: On the N., 240 feet on Mill street; on the E., 110 feet on a 30-foot alley; on the S., 240 feet on an alley; on the W., 110 feet by a 30-foot alley; and being all of lot Nos. 1, 2, 3, and 4, all of block No. 8, as per plat of Johnson & Murry's addition to the town of P.; being all of said block No. 8 in said addition to P., Tulare county, Cal." Counsel offering to follow it with a plat of the addition referred to, *held*, that an objection to the deed because it described nothing, was properly overruled.—*Redd vs. Murry (Cal.)*, 24 *P.* 841.

6. A deed having described the land by reference to the plat of an addition to a town, an unrecorded plat is, as against the grantor and his privies, *prima-facie* identified as the one referred to, by evidence that he afterwards exhibited it as the plat of the addition.—*Redd vs. Murry (Cal.)*, 24 *P.* 841.

7. A deed having described the land conveyed by reference to the plat of an addition to a town, parol evidence is competent to locate the land granted from *data* given in the plat, and it is not necessary as against the grantor to show that there was an actual survey of the addition.—*Redd vs. Murry (Cal.)*, 24 *P.* 841.

8. A deed described the boundary of the land conveyed as running to a certain creek, and "thence up the creek at high-water line in a north-easterly direction, the bearing is about north, 86° east." The creek ran south-westerly, but not at the angle named. *Held*, that the creek, being a natural monument, controlled the

course, and formed the boundary. Following Caspar *vs.* Jamison, 21 *N. E.* 743.—*Shepherd vs. Nave* (*Ind.*), 25 *N. E.* 220.

9. A deed of land bordering on a non-navigable lake or pond, commencing at a known monument on the shore of the pond, and running thence "along said pond to the outlet thereof," conveys only the land to low-water mark, and not to the center of the pond. Disapproving Ledyard *vs.* Ten Eyck, 36 Barb. 125.— *Gouverneur vs. National Ice Co.*, 11 *N. Y. S.* 87.

10. Where a patent describes a line as beginning at a corner on a branch and running "up the branch and binding thereon," the line must follow the water-course, and not the courses and distances as found by survey.—*Bailey vs. McConnell* (*Ky.*), 14 *S. W.* 337.

11. A deed of lots according to a plat on which the lots are bounded on one side by an alley, passes title to the center of the alley, where the grantor's title extends thereto. Following Schneider *vs.* Jacob, 5 S. W. 350.—*Jacob vs. Woolfolk* (*Ky.*), 14 *S. W.* 415.

12. For over twenty-five years a fence had stood between plaintiff's and defendant's lots. The owners of the lots had always thought that the fence was in the right place, and on the line. When the fence was originally built, or under what circumstances, did not appear. The only change made in the fence was that eight years prior to defendant's tearing it down, a new fence had been built in place of the old, which had, by direction of the then owner of defendant's lot, been placed three inches further thereon than the old fence. *Held*, in ejectment, that the owners of the lots having acquiesced in the line of the old fence for over twenty years, defendant was precluded from asserting that it was not the true line.— *O'Donnell vs. Penney* (*R. I.*), 20 *A.* 305.

13. Where land is described as bounded by the center line of a street extended, and the street has never been opened or dedicated adjoining such land, the mention of the street does not amount to a dedication.— *Sanford vs. City of Covington* (*Ky.*), 14 *S. W.* 497.

14. Where the owner of an entire tract has it surveyed and laid off into lots and streets, and a map made of the survey, and then sells the lots at auction before the map is filed for record, but does not deliver the deeds until after it is recorded, there is a complete dedication to the public of the streets designated on the map, and a purchaser at the auction sale at which the map was

used to inform purchasers of the location of the lots and streets cannot close the street, though his deed includes the land to its center, for that is simply a conveyance of the legal title subject to the public easement.— *Griffiths vs. Galindo* (*Cal.*), 24 *P.* 1025.

15. Where in a platted block the lots are marked on the plat as having the same number of front feet each, except one, the specific dimensions of which are also marked, and a survey shows that the whole block contains more front feet than are marked on the plat, the excess must be distributed between all the lots, and not given to that lot only which differed in its dimensions from the rest.— *Pereles vs. Magoon* (*Wis.*), 46 *N. W.* 1047.

16. Plaintiff conveyed part of a tract of land, separated from his other land by a road. He built a fence along his side of the road, and maintained it for nearly thirty years. He then attempted to move his fence nearer the land sold, claiming that the old fence did not correctly mark the boundary of the road. The evidence was conflicting. *Held*, that plaintiff was bound by the line as marked by his first fence.— *Sherman vs. Hastings* (*Iowa*), 46 *N. W.* 1084.

17. Where the description of land calls for another survey on the west and for a chestnut-tree as its south-west corner, and the adjoining corner of such other tract is described in its survey as being a fixed distance from a third survey lying on the west, it is a question for the jury whether this last point, or a chestnut stump further west, claimed to be the original monument, is the true corner.— *Bushey vs. South Mountain M. & I. Co.* (*Pa.*), 20 *A.* 549.

18. The dispute as to a boundary was as to the location of a quarter-section corner according to the original government survey. The commissioner reported that it was in the center of the section line, which was the point at which such corners were usually established, and which would give to the owners of each quarter section the same amount of land. The field-notes of the government survey, made in 1851, called for two burr-oak trees of a specified diameter, at specified distances from the quarter-section corner; and the commissioner reported that he found the stumps of two burr-oaks by measuring the specified distances from the center of the section line. *Held*, that it was error to set aside the commissioner's report, and to enter judgment to the effect that the quarter-section corner is located at a point 20 rods west of the center of the section line, though two burr-oaks bearing certain marks stand in

substantially the position called for in the field-notes measuring from that point; the testimony being conflicting as to character of the marks and the diameters of these trees in 1851, as shown by their present diameters.— *Yocum vs. Haskins* (*Iowa*), 46 *N. W.* 1065.

19. Under Acts 15th Gen. Assem. Iowa, c. 8, permitting a commissioner to be appointed by the district court to survey and establish disputed boundaries between parties, it is competent for the court to appoint such a commissioner on plaintiff's application, even though defendant claims title by prescription up to the line claimed by him; for, if defendant's claim is sustained by the evidence taken before the commissioner, that will terminate the investigation.— *Plank vs. Reinhart* (*Iowa*), 46 *N. W.* 1005.

20. Although it is a fundamental rule that the actual beginning corner must control in locating original surveys, yet when a survey is made upon paper, and not upon the ground, the intentions of the parties making the survey should control, which intention is to be ascertained by all the facts and circumstances connected with the case.— *Ocean Beach Ass'n vs. Yard* (*N. J.*) 20 *A.* 763.

21. There being evidence that a corner described in the field-notes with the bearing trees was found and identified on the ground, it is error to refuse a charge that calls for distances, and quantity must give way to calls for natural and artificial objects, and it is not sufficient to charge that "calls for surveys are important in the following order: (1) Calls for natural objects; (2) calls for artificial objects; (3) calls for course and distance,— but neither absolutely controls another class," where such other class more truly indicates from the evidence the true locality of the land in controversy.— *Titterington vs. Trees* (*Tex.*), 14 *S. W.* 692.

22. Plaintiff platted as an addition to a city, land of which he was owner, and signed, acknowledged, and recorded the plat as required by the laws of Oregon. Of that part of the land fronting on M. street, he dedicated enough to make the street 46 feet wide. In front of the land adjoining his, the street was 60 feet wide, and the opposite side of the street along the whole of both fronts was a straight line. He then sold lots in this addition by a map which was an exact copy of his plat, except that the dimensions of the lots were not given on the map, and that both sides of M. street, as it appeared on the map, were straight lines, thus showing the street of uniform width. *Held*, that this was not sufficient, in

the face of the plat, to show a dedication by plaintiff of enough land to make M. street of the same width in front of his property that it was in front of the adjoining property.— *Hogue vs. City of Albina* (*Or.*), 25 *P.* 386.

23. To establish the existence of a highway by dedication by deed, it must appear that the grantor was the owner of the land when the dedication was made.— *Warren vs. Brown* (*Neb.*), 47 *N. W.* 633.

24. A plat of lands, made by the owner, showing lots, blocks, and streets, but not acknowledged and recorded as required by 2 Terr. Laws Mich. 577 (1 How. St. c. 32), does not operate as a statutory dedication of the fee of the streets to the county in trust for the municipality intended to be benefited.— *Village of Grandville vs. Jenison* (*Mich.*), 47 *N. W.* 600.

25. When the acts of the owner of the land are relied on to establish a dedication of land for the purposes of a public road, an acceptance of the same by the public must be proven.— *Warren vs. Brown* (*Neb.*), 47 *N. W.* 633.

26. In order that a plat showing lots, blocks, and streets may operate as a common-law dedication of an easement in the street to the public, there must be an acceptance by the public within a reasonable time; and it acquires no rights in a platted street which it failed to use for thirty-four years, during a part of which time an abutting owner occupied the same by buildings erected thereon.— *Village of Grandville vs. Jenison* (*Mich.*), 47 *N. W.* 600.

27. Plaintiff and defendant owned adjoining mining lots. Defendant mined a quantity of ore on the side of his lot next to plaintiff. A corrected survey of the whole tract showed that the land from which this ore was taken was within the true lines of plaintiff's lot, and he brought forcible entry and detainer against defendant. The evidence showed that when the parties went into possession, the lots were marked by stakes, and that defendant's operations had been confined to his own lot as originally staked off. *Held*, that these stakes were monuments which must prevail over the courses and distances of the subsequent corrected survey. — *Jones vs. Poundstone* (*Mo.*), 14 *S. W.* 824.

28. In trespass to try title to land alleged to be part of the M. survey, it appeared that the north-east corner of the M. survey was known, and the course called for in the patent from that corner was "south, 60 west." At the north-west corner the call was for

"a stake whence a willow bears north, 63 west, 98 *varas*." Neither the stake nor bearing tree could be found, and a line drawn from the north-east corner to the stone, which plaintiff's witness testified marked, and had been for thirty years recognized as, the true north-west corner, would be "south, 61 west," and the land in controversy was that included between said lines. *Held*, that the court properly charged the jury that in locating said line they should be governed by the calls in the patent, and, if the evidence satisfied them as to the true location of said line as originally run and marked by the stakes and bearing tree mentioned in the patent, they should be governed by such line, but if the location of the stakes and bearing tree, as they existed when the patent was issued, was not satisfactorily established by the evidence, they should be governed by the courses and distances of said line as called for in the patent.—*Boydston vs. Sumpter* (*Tex.*), 14 *S. W.* 996.

29. The patents for two grants of land did not call for each other as coterminous boundaries, and neither was described with reference to the other, but each grant was described as being bounded, along the sides nearest the other, by a river, one by the left bank and the other by the right bank, and in each courses and distances were given as the meander line of the bank referred to. In an action to establish the boundary between the two grants, the court below found that the river had changed its channel considerably since the patents were issued, and that the banks, as they then existed, could not now be found or traced. *Held*, that it was error for the court below to adopt, as the boundary between the two grants, a line established by plaintiffs' surveyors by running the courses and distances along the river bank as called for by defendants' patent, and then, for the purpose of establishing the line of plaintiffs' grant, laying off a line parallel to the line of defendants' grant so surveyed, and a uniform distance of seven chains therefrom, allowing that to be the width of the river running between the two grants, where the testimony is undisputed that the river, now and of old, varied in width at different points. Beatty, C. J., and Sharpstein J., dissenting.—*Martin vs. Cooper* (*Cal.*), 25 *P.* 262.

30. Where a deed grants "a strip of land forty feet wide along the bank of the Willamette River . . . for the purpose of a road or right of way," but fails to fix the side lines of such strip,

evidence of the situation and conduct of the parties and of the nature of the ground is admissible to show that the line next to the river was intended to run along the top of the bank instead of along the water-line.— *Wills vs. Leverich* (*Or.*), 25 *P.* 398.

31. On a question whether a sheriff, in executing a writ of possession, correctly interpreted a part of the decree calling for a line from a point on a lake; "thence southward with the meanders of said lake 405 *varas* to the mouth of the lane on the south bank; thence south,"— the jury were warranted in finding that he should have run the line south from the mouth of the lane instead of from a point beyond to which the 405 *varas* carried him, since that point was necessarily variable, depending upon the distance from the water-line at which the meanders were run.— *Jackel vs. Reiman* (*Tex.*), 14 *S. W.* 1001.

32. Plaintiff in ejectment claimed a line different from that laid down in the survey, by reason of the known location of his N. E. corner. Plaintiff testified that a stake was set at this corner by the original surveyor; but this stake only stood two years. Some years after, a surveyor started with the initial point of plaintiff's survey, and running on course and distance found the witness tree of the N. E. corner, and located that corner as laid down in the original survey; and the line so run was treated as the true line by adjoining owners without objection from plaintiff. *Held*, that the evidence in support of the N. E. corner, as claimed by plaintiff, was sufficient to prevail over the courses and distances. — *King vs. Brigham* (*Or.*), 25 *P.* 150.

33. A patent by the federal government, which in terms bounds the land on the margin of a stream navigable in fact and above tide-water, carries the title only to the water's edge, and not to the center of the stream. Affirming 11 P. 873.— *Packer vs. Bird*, 11 *S. Ct.* 210.

34. Where a conveyance of a city lot describes it as beginning 298 feet from the intersection of two streets, "at or in front of the middle of a party-wall," the party-wall, being a fixed monument, must be considered as the beginning point of the description, though it is only 293 feet from the intersection of the two streets. Affirming 55 N. Y. Super. Ct. 359.— *Muhlker vs. Ruppert* (*N. Y.*), 26 *N. E.* 313.

35. Where the calls of the field-notes of the title papers under which both parties claim begin at the corner of a certain survey,

and plaintiff's title papers locate that corner at a rock set in the ground, which is there at the time of trial, but the survey made by order of court shows that this rock is not at the place where the calls in the original survey would place it, the line is not to be determined by the recent survey, nor by the course and distance of the original survey, but it is to be located by the jury where it appears from the evidence to have actually been located originally.— *Evans vs. Foster* (*Tex.*), 15 *S. W.* 170.

36. October 18, 1833, the government of Texas granted to Maximo Moreno a tract of 11 leagues of land extending northward from the San Andres River, which runs diagonally south-eastward, across its front. The original survey called for a stake in the prairie at the N. W. corner, and for two hackberries at the N. E. corner. The stake had entirely disappeared. Running the courses and distances forward, from the S. W. corner, made the east line 4,000 *varas* too long, gave no trace of the hackberries at the N. E. corner, and disclosed serious discrepancies in the other natural calls. Running them backward from the S. E. corner, gave two blazed hackberries at the N. E. corner, and corresponded much better with the other natural calls, but made the west line 4,000 *varas* too short. The north line, as called for, running forward, was blazed on the trees, and the east line was blazed northward beyond the hackberries about 4,000 *varas*, but the distances of the north line made it fall short of the east line by about 570 *varas*, and the evidence tended to show that these marks were made about thirty years after the original survey. The court charged that the jury must follow the tracks of the surveyor so far as discoverable with reasonable certainty upon the ground, and that marked trees designating a corner or line should control both courses and distances. *Held* proper, and a charge that if the marked north line, and the east line above the hackberries, were run at the original survey, they must be considered the true boundaries, would have been misleading as an independent proposition, because it ignored the evidence tending to locate the corner at the hackberries, which was the most controlling evidence in the case.— *Ayers vs. Watson*, 11 *S. Ct.* 201.

37. An old map found in the general land-office of Texas, and reputed to be the work of the original surveyor of the Moreno grant, contained a sketch of the survey, with notes indicating that the lines were run in the opposite direction from the S. E. corner.

Defendant asked a charge that if the testimony was insufficient to identify the hackberries found as the hackberries called for in the grant, and the jury could not fix the N. E. corner or the north line by any other marks or monuments, then they must fix it by the courses and distances of the first and second lines of the survey, extending the north line the 570 *varas* necessary to make it intersect the blazed east line. The court had charged the same, in substance, with the additional qualification that the jury must first be satisfied that the original survey was not commenced from the S. E. instead of the S. W. corner. *Held*, that this qualification was necessary and the charge asked was properly rejected.— *Ayers vs. Watson*, 11 *S. Ct.* 201.

38. Where the distances of a survey have been actually measured upon the ground, the courses and distances may be reversed when by so doing they more nearly harmonize with the natural calls of the patent, and the "beginning" corner does not control more than any other corner which is definitely ascertained. — *Ayers vs. Watson*, 11 *S. Ct.* 201.

39. The owners of a strip of land, on the boundary between themselves and defendants, are not estopped from asserting their title, after disputing defendants' right to enter thereon, because, misled by defendants' claim and some advice they had obtained in reference thereto, they acquiesced for less than twenty years in the possession of defendants, who did nothing in reliance on their silence. — *Hinkley vs. Crouse* (*N. Y.*), 26 *N. E.* 452.

40. Where adjoining land-owners employ a surveyor to run the boundary line between them, not because they have had a dispute about it, but merely because they are ignorant of its exact location, the line so run, if incorrectly located, is not conclusive on the parties, even though they acquiesce in it believing it to be correct. — *Pickett vs. Nelson* (*Wis.*), 47 *N. W.* 936.

41. The owner of land who has agreed to sell it, but who afterwards receives a release of the contract, is not bound by the action of the other party to the contract in agreeing with an adjoining owner as to the boundary line between them, even though he aids in making the survey. — *Pickett vs. Nelson* (*Wis.*), 47 *N. W.* 936.

42. Where the field-notes of a survey, and maps made by different county surveyors, show that the west line of a certain survey is the east line of a former survey, and that line is taken as the boundary for more than forty-seven years, the fact that the

courses and distances of the respective surveys show a gap between them is not sufficient, after such lapse of time, to prove that the surveys do not actually adjoin. — *Standlee vs. Burkitt* (*Tex.*), 14 *S. W.* 1040.

43. The fact that certain monuments marking the corners of a survey cannot be found, does not render the lines of the survey unknown or uncertain so that they can be proved by parol evidence, when the field-notes of the survey afford sufficient *data* for running the lines.— *Pickett vs. Nelson* (*Wis.*), 47 *N. W.* 936.

44. Where a corner, supposed to have been established by the government in the surveys of public lands, has been acquiesced in by adjoining owners of such lands for nearly ten years, and improvements made, and the land broken up to the line thus established, there is a presumption in favor of such corner being the true one, which can only be overcome by clear proof that it was not established by the government.— *Coy vs. Miller* (*Neb.*), 47 *N. W.* 1046.

45. In trespass to try title, it appeared that the original field-notes of the survey of the grant involved were made in English, and subsequently transcribed and translated into Spanish, and thus carried into the grant. The surveyor of the grant, one Johnson, and his chain-bearer, both testified that the survey was made but once, and in the year 1833, and the chain-bearer said it was made in the spring. In the general land-office there were on file original English field-notes of the survey corresponding exactly with the notes in the grant, excepting that they called for four intermediate streams, while the grant called for but two, together with a map of old surveys, including a sketch of the one in question. The field-notes were dated "Sunday, 21," and April 21, 1833, fell upon Sunday. Both notes and map were reputed to be the work of Johnson, and had been on file beyond the recollection of those connected with the office. In other litigation concerning the boundaries of the grant, these documents were held admissible by the Supreme Court of Texas. 13 S. W. 768. *Held*, that they were admissible in this case.— *Ayers vs. Watson*, 11 *S. Ct.* 201.

46. In ejectment, where defendant claims that the land is within the exterior boundaries of a rancho, and consequently not included in the patent to plaintiff, and supports this claim by the original petition, the *expediente*, the *diseno*, the act of judicial possession, various maps, decrees, and proceedings, and also by oral

testimony of witnesses as to the exterior boundaries of the rancho, the evidence may warrant a finding that the land in controversy is within the exterior boundaries of the rancho.— *Foss vs. Hinkell* (*Cal.*), 25 *P.* 762.

47. The fact that a patent describes the land as "the north-east quarter of the south-east quarter of section 8," instead of as lot 4, does not exclude from the grant any of the land that would properly be in lot 4, when it appears by the government plat that it was intended to pass lot 4, which was marked as containing the same number of acres as were granted by the patent.— *Sheppard vs. Wilmott* (*Wis.*), 47 *N. W.* 1054.

48. The fact that lot 4 is in two quarter sections, is immaterial, as a given fractional lot may be crossed by quarter section lines, when the lines of the plat show that it was not intended to extend the intersecting line of the adjoining quarter section so as to exclude from lot 4 the land in controversy, which is necessary to make up the number of acres as called for in the plat for lot 4.— *Sheppard vs. Wilmott* (*Wis.*), 47 *N. W.* 1054.

49. The tenant in a writ of entry claimed under a deed describing the land as 41.53 rods, bounded on the east and west by the lands of the grantor, but with nothing to fix either the east or west line. When the deed was delivered, the grantor pointed out four stakes, and told the tenant that the land between them was hers. By a later deed, under which the demandant claims, the grantor conveyed an adjoining lot by a description which overlaps the land between the stakes. The land claimed by the tenant includes 42½ rods, while the location of the line according to the calls in the demandant's deed would leave the tenant the full quantity called for by her deed. *Held*, that the tenant was entitled to all the land between the stakes.— *Hooten vs. Comerford* (*Mass.*), 26 *N. E.* 407.

50. A conveyance describing the land by lots, blocks, or government subdivisions, and adding at the end of the description, "also, together with all other lands that may not have been heretofore described belonging to said" grantor, passes title to a lot not expressly mentioned.— *Clifton Heights Land Co. vs. Randell* (*Iowa*), 47 *N. W.* 905.

51. A deed by the trustees for another part of the platted land, which describes the land conveyed by reference to the streets, and makes no reference to the beds thereof, and made in pursuance of a sale at public auction under the plat, and an advertisement con-

taining no reference to the beds of the streets, constitutes a dedication.— *Pitts vs. City of Baltimore* (*Md.*), 21 *A.* 52.

52. Under Rev. St. Ill. 1845, c. 25, div. 1, §§ 17–21, which provided for the recording of plats acknowledged by the owner of the land, the recording of a plat acknowledged by the attorney in fact of such owner does not operate as a statutory dedication of the streets.— *Earll vs. City of Chicago* (*Ill.*), 26 *N. E.* 370; *Thomsen vs. McCormick*, *Id.* 373.

53. The recording of a plat acknowledged by the attorney in fact of a land-owner does not operate as a statutory dedication of the streets; but where such owner afterwards sells land abutting on a street in such plat, his grantee takes title to the fee of the street burdened with an easement in favor of the public, since such sale amounts to a common-law dedication of the street.— *Earll vs. City of Chicago* (*Ill.*), 26 *N. E.* 370.

54. The fact that part of the land dedicated for a street does not belong to the dedicator does not avoid the dedication as to that part owned by him — *Earll vs. City of Chicago* (*Ill.*), 26 *N. E.* 370.

55. Where the owner of land makes a common-law dedication of a street, and then conveys the land on both sides of the street to one person, and the street is afterwards vacated, such person owns the fee in the land included in the street.— *Thomsen vs. McCormick* (*Ill.*), 26 *N. E.* 373.

56. Where an owner lays off his land into blocks and streets, makes a plat thereof, and sells lots indicated thereon by reference to such plat, the dedication of the streets thereupon becomes irrevocable.— *Hicklin vs. McClear* (*Or.*), 22 *P.* 1057.

57. Where parties owning contiguous estates derive title from a common author, and a controversy arises as to the boundary between them, the elder title must be first satisfied, and, when that title conveys a fixed quantity of land, the holder is entitled to take such quantity.— *Keller vs. Shelmire* (*La.*), 7 *So.* 587.

58. Where a patent of land is issued with boundaries as described in a survey and map made by a government surveyor, who has also made field notes giving not only courses and distances, but also monuments and the various topographical features of the country, the calls for monuments will control the courses and distances in relocating the boundaries of the patent.— *Tognazzini vs. Morganti* (*Cal.*), 23 *P.* 1085.

59. The city of Louisville condemned a certain strip of land for railroad and sewer purposes, and, after constructing a road-bed along this, it conveyed to the L. & N. R. Co. "its title to the road-bed, bridges, and right of way" along the entire route, and "all the land belonging to the city," between certain streets, "for depot purposes." The railroad company had formerly occupied a right of way for a double track on other streets, and the city, in consideration of the change of the railway to the street forming the line of the road in the conveyance, agreed to furnish the company a road-bed. *Held*, that along the rest of the route nothing was conveyed outside of the road-bed.— *Long vs. Louisville & N. R. Co.* (*Ky.*), 14 *S. W.* 78.

SKETCH OF ROBERT CLARK, JR.

ROBERT CLARK, JR., was born in Delaware county, New York, August 4, 1804. He was a son of Dr. Robert Clark, and was one of a family of twelve children. The family was of Scotch descent. Dr. Robert Clark was a man of marked ability, having represented the State of New York in the national Congress. A staunch adherent of the Presbyterian faith and an uncompromising Whig, he earnestly endeavored to inculcate in the minds of his children his own religious and political convictions. Young Clark had the advantage of a good education in an academy in his native county.

In 1821 Dr. Clark was appointed registrar of the United States Land Office at Monroe, Mich., to which place he immediately removed with his family, and there died about 1840. This appointment induced his two sons, John A. and Robert, Jr., to adopt the profession of civil engineers, which they followed for the remainder of their lives. When not more than eighteen years of age, Robert, Jr., commenced the practice of his profession by a survey of two islands known as the "Twin Sisters," and lying at the mouth of the River Raisin. On the ninth day of December, 1823, he received his first regular government contract from Edward Tiffin, Surveyor General of the United States, in which he agrees "that he, the said Robert Clark, Jr., in his own proper person, with the assistance of such chainmen and axmen as may be necessary (being first duly sworn), agreeably with the laws of the

United States, and such instructions as he may receive from the said Edward Tiffin, Surveyor-General, will faithfully lay out, survey, and subdivide into sections the following townships of land, to wit: Townships 4, 5 S, R 1 E; Ts. 5, 6, 7 S, R 1 W, situated south of the base line and east and west of the principal meridian, in the southern district of the Territory of Michigan." By inspection, this work, proved to have been well done, and on the sixth day of May, 1825, he received a contract to survey townships 4, 5 S, of R 4, 5, 6 W, and on the 15th of December of the same year, secured an additional contract for the survey of townships 4, 5, 6 S, R 2, 3 W. Among his other contracts were the following: In 1826, Townships 4, 5 S, R 7 W; Ts. 3, 4 S, R 8, 9 W; Ts. 2, 3, 4 S, R 10 W; Ts. 3, 4 S, R 11 W. In 1828, fractional townships 8, 9, 10 S, R 4 W; fractional Ts. 8 S, R 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 W. In 1829, Ts. 1 S, R R 12, 13, 14, 15, 16, 17 W. In 1830, the exterior lines of towns 7 to 17 N, R 1 E; 12 to 17 N, R 2 E; 14 to 17 N, R 3 E; 7 to 17 N, R 1 W; 7 to 16 N, R 2 W; 7 to 14 N, R 3 W; 7 to 12 N, R 4 W; 7 to 10 N, R 5 W; 7, 8 N, R 6 W; 7 N, R 7 W.

All of the foregoing were in the then Territory of Michigan. During the years employed in this labor, Mr. Clark spent most of his time among the Indian tribes. He became familiar with their language, habits, and character, mingled in their sports and councils, or joined with them in the pleasure and excitement of the hunt and chase. At the breaking out of the Blackhawk War, in the spring of 1832, Mr. Clark offered his services in defense of the sparsely settled country of Southwestern Michigan. Gov. Porter, recognizing the value of the man, commissioned him a lieutenant of cavalry, and he was assigned to duty in the 12th Michigan Militia, in which command he served until the restoration of peace.

In the winter of 1832–33, he surveyed in what was then known as the Northwest Territory, T. 3. R. 1. 2, 3 W, 4th Principal Meridian; T 4, R 1, 2, 3 E and 1 to 6 W; Ts. 5, R 5, 6, 7 W, and Ts. 6, R 6, 7 W. This work was situated north of the north boundary of the State of Illinois, and east and west of the 4th Principal Meridian, in what is now the State of Wisconsin. This last survey was an extremely difficult and hazardous undertaking. Starting from his home in White Pigeon, Mich., on the 4th day of October, 1832, he traversed the whole distance through forests and across prairies, fording the streams swollen by the autumnal rains, and finally arrived at his work on the 27th of the same month. Provisions were high and difficult to obtain, but the abundance of game assisted

them in securing the necessary food. The country was very rough and rugged. We find this entry in his journal: "Feb. 21, 1833. Brush! brush! brush! Oh, this terrible Platte country! No wonder that no man in the mines knows anything about it. The largest tracts of it are inaccessible even to wild beasts. Nothing but a ragged surveying party could ever penetrate its horrid recesses. This day we tore through four miles." In the same journal, under date of April 6, he writes: "Last night at 2:30 A. M., an express came to camp with news that 3,000 hostile Indians were on the march, and probably by that time had sacked Galena. At daylight, after breakfast, packed up the horses to go to some fort. Found that during the night most of the inhabitants of the country had 'forted.' About 9 A. M., news came that the report was groundless. It is now ascertained that a man was chopping wood near the mouth of Rush Creek, some twenty or thirty miles from Galena, when two men came up the river and gave the Indian yell, and he ran for Galena. We became reconciled, and got to work again about 11 A. M." Twice their camp was destroyed by forest fires, with the loss of tents, provisions, etc., and the party was obliged to bivouac, and subsist as best they could, until food and shelter could be obtained. The work was finally finished on the 15th day of April, 1833, when Mr. Clark and his companions returned to White Pigeon.

During the years 1833–36, Mr. Clark was variously employed as District Surveyor of St. Joseph county, Mich., and upon government surveys in Illinois and Missouri. At that time considerable ill feeling existed between the Illinoisans and Missourians. He tells of a laughable incident illustrative of this hostility. While traveling through Missouri with his company of surveyors, he applied one evening at the cabin of a settler for shelter for himself and companions. The settler's wife eyed him suspiciously and said: "Be you 'uns Suckers or Pukes?" "Neither," said Mr. Clark, "we are Wolverines." "What kind of animal is that?" said the woman, still incredulous. Clark explained that the wolverine is not a beast of hostile proclivities, but is as gentle and mild-mannered as a lamb. This explanation restored entire confidence, and the travelers were treated to the best the cabin afforded.

Once while surveying on the eastern shore of Lake Michigan, a huge, gaunt wolf persisted in following the party hour after hour. Clark remarked that that wolf looked as though he had n't eaten

anything for a week, and would relish a dish of surveyor, rare done. One of his companions laughingly proposed to see what he had for his last meal. Raising his rifle, he shot the wolf dead in his tracks. Upon examining the stomach of the dead animal, it was found to contain only the knotted end of a tarred rope, which he had doubtless picked up on the beach of the lake.

Mr. Clark's last contract was for the survey of a number of townships north of Grand River, and not far from the present site of the city of Grand Rapids. About the 9th of March, 1837, he started from White Pigeon for this work. Mr. S. P. Williams, now living in Lima, Ind., says: "One morning, early in March, 1837, as I was passing along the streets of White Pigeon, I observed my friend Clark approaching, mounted on his favorite black horse, with his compass and Jacob staff fastened behind his saddle. Of medium size, without an ounce of superfluous flesh, a rosy, fresh countenance, hardy, cheerful, and in the prime of life, he was a perfect specimen of the early pioneer of Michigan. Extending his hand to me, he said: 'Good-by, my friend, I am off for the Saginaw country.' 'Good-by, and good luck to you,' said I. 'Thank you,' said he, 'I have need of your good wishes, for I am going to a rough, cold country, and have a hard job before me.'" Turning his horse's head to the northward, he followed the old Indian trail to Kalamazoo, stopping with his friend, T. P. Sheldon, thence north through the forest, arriving at the Grand River the next day. After procuring the necessary supplies and camp equipage, he commenced his work on the 19th of March. The next day, March 20, while returning to camp from work in the field, he was suddenly stricken with apoplexy, and died immediately. Thus at the age of 33, "while yet in love with life, and enraptured with the world, he passed to silence and pathetic dust." His body was placed on the back of his faithful steed, and transported to his home in White Pigeon, where he was buried.

Robert Clark, Jr., was a man of decided character, and of liberal religious and political opinions. Prudent in financial matters, scrupulously honest and exact in all business intrusted to him, he won the esteem of those with whom he was thrown in contact. His greatest delight was in his family, and his domestic relations were exceptionally happy.

An expert and fearless rider, he was an excellent judge of horseflesh, regarding his horse more as a companion than a slave. About 1830, he purchased a very fine black saddle horse of

P. Marantette, an Indian trader who resided near the present site of the village of Mendon, St. Joseph county, Mich. This horse carried him on several trips from White Pigeon to Cincinnati and back, and was with him on his journey to Wisconsin. It is said that on one occasion he rode him from White Pigeon to Monroe in a day and night. After Mr. Clark's death, this horse remained at the old homestead in White Pigeon, where he was kindly cared for until his death in 1857.

Mr. Clark was married on Dec. 29, 1831, to Mary E. Fitch, a daughter of Judge Charles B. Fitch, of Lockport, Mich. She still survives him, and makes her home with her son in Chicago. Mr. Clark left two children, Robert Bruce and John M. Bruce became a prominent and successful merchant in Chicago, where he died in 1864. John M. was educated with the expectation that he would follow the profession of his father. He graduated as a civil engineer from the Rennsalaer Polytechnic Institute, of Troy, N. Y., in the class of 1856; followed the profession in the States of Iowa, Colorado, and the Territory of New Mexico; was in the latter Territory during the war, and came to Chicago from there on the death of his brother, where he has since resided. He has filled several positions of trust, and is now collector of customs for the port of Chicago.

Robert Clark, Jr., at the time of his death, was possessed of what was regarded as a fair fortune in those days, consisting almost entirely of wild lands. The hard times which followed the panic of 1836 greatly depreciated the value of this property, and it was with the greatest difficulty that his widow was enabled to support herself and children, and prevent the land from being sold for taxes.

Mr. Clark's brother, John A., who learned the business of surveying with him, came west in 1840, and was employed by the government to survey the 3rd Principal Meridian, which runs through the State of Indiana its entire length from north to south. He said he did not see a white man outside of his own party on this trip, from the time he left Chicago until he returned there after the survey was completed. John A. was appointed by President Lincoln as Surveyor General in New Mexico and Arizona, and was afterward transferred in the same capacity to Utah. He was a skillful engineer and a good man.

O. H. Todd.

BUSINESS TRANSACTIONS

Of the Michigan Engineering Society for the year 1890-91.

THE annual convention was held in the pioneer room at the State Capitol, and was fully attended. Owing to ill health, the Secretary was unable to be present at the convention. A stenographer was employed to report the proceedings, but no report was furnished of the business transactions or of the addresses by Professors Greene and Denison. The reports of discussions were so imperfect as to be of no value whatever, further than to indicate in an imperfect way who took part in them. This accounts for the very meagre report that we are able to give of the meeting. The lack of a report of the discussions has been partly made good by some of the members, who have written out what they wished to say on the subjects presented. Being unable to procure Prof. Greene's address on iron tests, the discussion has been omitted. At the business meeting, the annual reports of the Secretary and Treasurer were presented. They are as follows: —

SECRETARY'S REPORT.

The Secretary would respectfully report that since the last meeting, he has transacted the following business for the society: —

Immediately after the Detroit convention, the contract for publishing the "Annuals" was let to W. C. Gage & Son, of Battle Creek. Advertisements were solicted by the Secretary as far as possible for him to do so, and the aid of Mr. G. K. Brandon was called in to assist in the work, which he did on a commission.

The work of publication was pressed forward as fast as circumstances would permit, and the "Annual" was sent out to the

members who were not in arrears for dues, the 1st of June. Exchanges were effected with the societies of Arkansas, Iowa, Indiana, Ohio, the Provincial and Dominion Land Surveyors, and the University of Michigan. These were sent to the members in the fore part of September by express. Letter ballots were sent out for members, and canvassed by the Secretary on the 1st of April, and the new members included in the published list in the "Annual." Letter ballots for officers were also sent out. In July, Prof. Carpenter sent in his resignation as President, and withdrew his name from the list of candidates for the coming year. A meeting of the Board of Directors was held at Ann Arbor, July 11. Prof. Carpenter's resignation was accepted, and a supplementary ballot for President was ordered. Ballots were sent out accordingly. The Board of Directors held their annual meeting at Lansing, October 9, and canvassed the ballots for officers, and the following were declared elected: President, J. B. Davis; Vice-President, Geo. L. Wells; Secretary and Treasurer, F. Hodgman; Directors, Geo. E. Steele, M. E. Cooley, and C. E. Greene. A preliminary program was prepared and sent to every member and every surveyor in Michigan whose address could be procured, as well as to a large number of others. The Secretary exceedingly regrets that the condition of his health is such as to prevent his attendance at this convention, but he has done all in his power to make it a successful meeting, and he sends his best wishes and kindly greetings to all the members, old and new, and wishes them a pleasant and profitable meeting.

TREASURER'S REPORT.

THE treasurer respectfully reports the following moneys received and disbursed by him during the year ending October 9, 1890: —

RECEIPTS.

Cash on hand, Oct. 9, 1889	$ 61 57
Received from members for fees, dues, and postage	221 30
" " advertisers	257 50
" " reports sold	2 50
Total	$542 87

EXPENDITURES.

Paid W. C. Gage & Son for "Annuals" and other printing	$260 38
" the secretary	50 00
" stenographer	29 12
" for illustrations not in Gage bill	29 00
" " freight and express on exchange reports	18 25
" " postage and envelopes	43 73
" expenses of Board of Directors	9 00
" commission to Brandon for "Ads"	14 00
" other expenses getting out "Annuals," etc	15 85
Amount on hand Oct. 9, 1890	73 54
Total	$542 87

These reports were accepted, and resolutions were passed expressing appreciation of the work done by the secretary, and voting him $100 for past services.

The following persons were nominated for officers for the ensuing year: —

For President, W. F. Durand.

For Vice-President, Geo. E. Steele, M. E. Cooley.

For Secretary-Treasurer, F. Hodgman.

For Directors, C. E. Greene, A. J. Teed, Geo. E. Steele, Wm. Appleton, Gardner S. Williams, and J. B. Davis.

The following names were approved by the Board of Directors for membership, and ballots have been sent out, and the applicants elected: —

Senior Members, F. S. Dewey, Alpena; P. O'Connell, Lansing; H. L. Thayer, Lansing; Philip B. Woodworth, Lansing; H. E. Terry, Saginaw; Charles H. Redman, Grand Rapids; W. H. Vande Voort, Lansing; Orlando J. Root, Lansing.

For Junior Member, Ernest Sellers, Lansing.

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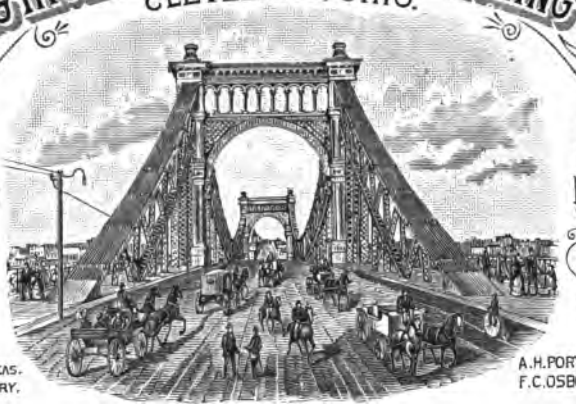

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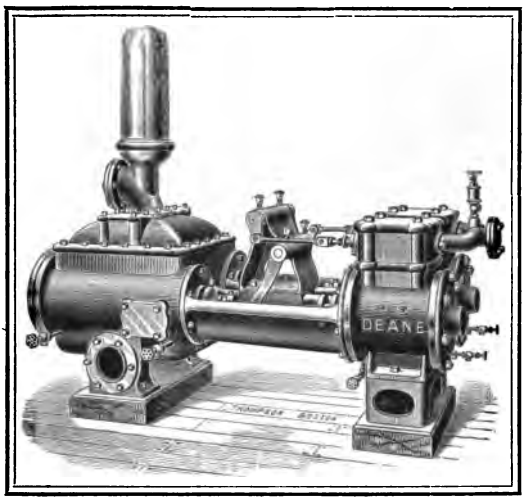

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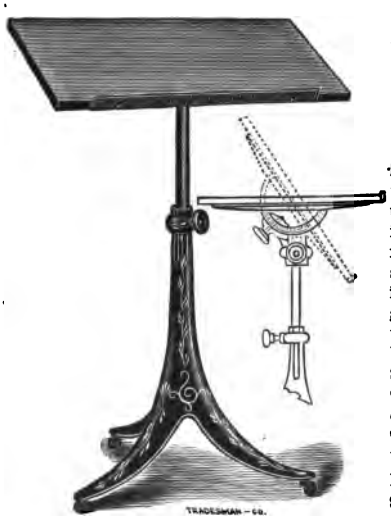

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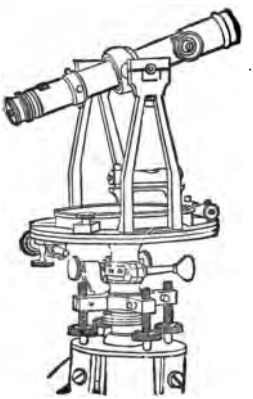

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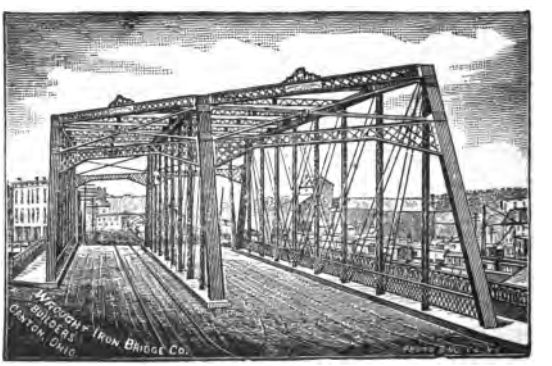

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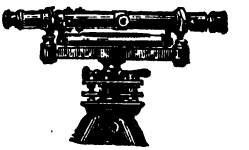

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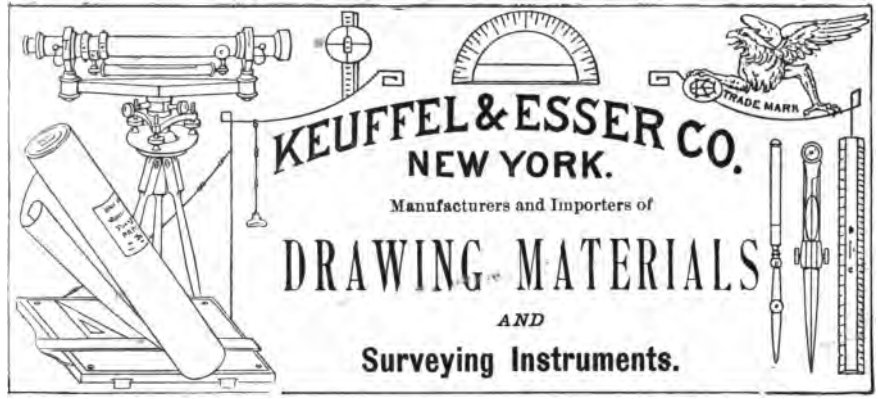

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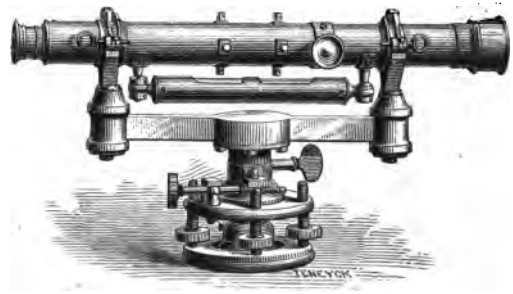

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